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CONTENTS OF THIS ISSUE

Contents of previous issues can be found by consulting the Industrial Arts Index at your library

General

Developments During 1935 in the Chemistry of Silk and Silk Processing 451
Walter M. Scott

Latest Advances in Pin Tenter Drying 470
B. M. Jones

Locating Oil Wells with Dyes 472
F. R. Cozzens

Modernizing the Dyehouse for Reduced Costs 473

Book Reviews 477

New Products: Trade Notes 478

Proceedings of American Association of Textile Chemists and Colorists

A Study of the Mercerization Process P458
S. M. Edelstein

Tentative Program for Annual Meeting P466

Committees for Annual Meeting P466

Unemployment Register P467

Editorial:

Chemical Exports 469

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AMERICAN
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VOLUME 25 AUGUST 24, 1936 NUMBER 17

Developments During 1935 in the

Chemistry of Silk and Silk Processing

WALTER M. SCOTT, Ph.D.*

Chapter I

The Chemistry of Raw Silk

SILK COCOONS AND THE SILKWORM

THE previous review indicated that detailed and fundamental studies of the silkworm were being carried on in Italy. These studies dealt particularly with modifications of the culture of the silkworm designed in some cases to improve the quality of the silk produced and in others to accelerate the production of the silk.

Later reports from France reveal that the silkworm has received a certain amount of attention in that country also. A study has been made of the fluorescence of silkworms of the type *Bombyx mori L.* in Wood's light. It was found that the fluorescence varied from yellow to violet-blue. There seemed to be a relationship between the intensity of the fluorescence and the condition of the two silk glands in the worm. It appeared that a selection of the living worms under Wood's light might be the means of eliminating those with defective glands.

A new use for the oil obtained from silkworms was proposed in an American patent. It was claimed that worn silk yarn could be rejuvenated by passing it in a single strand through a body of silkworm oil and then rubbing it as it left the bath.

A method for the determination of chlorine in cocoons has been developed. It was found that the chlorine content based on the weight of the cocoons when dried at 140° C. varied from 0.02 per cent to 0.07 per cent. The average of a number of determinations indicated a mean chlorine content of 0.04 per cent.

SILK REELING

An improved patented method for reeling silk was discussed in the previous review. It consisted in pretreating the cocoons, first with a dilute solution of ammonia or an amine and then with a dilute solution of a caustic alkali. In a more recent patent it was claimed that the quality of the reeled silk was improved by neutralizing the filaments during their passage to the reeling device. This was accomplished by drawing the filaments through a very dilute bath of an acid or an acid salt, possibly with the addition of a certain amount of sulfonated castor oil.

This article is the third in a series of reviews written exclusively for this journal. The first review summarized the progress which had been made up to the end of the year 1933 in the development of the fundamental chemistry of raw silk and the chemical processes which enter into the transformation of raw silk into finished fabric. It was published in Volume XXIII, Issues No. 9, 10, 11, 12 and 13. The second review, covering the year 1934, was published in Volume XXIV, Issue No. 16. The present article carries the summary through the year 1935.

As in the previous articles, the subject is divided into the following five chapters:

I. The Chemistry of Raw Silk.
II. The Soaking of Silk.
III. The Degumming of Silk.
IV. The Weighting of Silk.
V. The Dyeing and Finishing of Silk.

THE CHEMISTRY OF SERICIN

From Hideo Kaneko of Japan has come further contributions to our knowledge of the chemistry and the colloidal behavior of sericin. It has been established that in general, the reactions shown by aqueous sericin solutions obtained from the cocoons of *Bombyx mori* are indicative of the "kaijo" of the cocoon. As explained in a previous article, the "kaijo" is the weight of raw silk reeled per hour under the same conditions and it is therefore a measure of the comparative reeling efficiency shown when the cocoon is unwound.

Variations in the "kaijo" are accompanied by variations in the color produced in the corresponding sericin solutions in the Biuret reaction, in Engel's reaction and in the arginine color reaction. With Makri's reaction a yellowish green color develops on mixing 0.5 c.c. of an alcoholic solution of sericin with three drops of a 3 per cent alcoholic solution of alpha naphthol and 5 c.c. of 75 per cent sulfuric acid, but this color is only slightly affected by differences in "kaijo."

The gold number of sericin, which varies inversely as its colloidal protective value, is smaller with good "kaijo." The pH giving the maximum gold number varies from 4.2 for good "kaijo" to 4.3 for bad "kaijo." Above 60° C. the colloidal protective power of sericin increases remarkably, but it drops on ageing, owing to the aggregation of the sericin particles.

Sericin shows excellent emulsifying action which is at its best when the "kaijo" is good. The emulsifying power of a sericin solution varies with the pH as this affects the surface tension and the viscosity.

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Sericin has the power to inhibit the reaction in which pyrogallol is catalytically oxidized in the presence of pentamine cobalt chloride. When the "kaijo" is good the sericin is a more effective inhibitor. Ageing decreases the inhibiting power of sericin.

Sericin forms thermo-reversible gels which tend to be clear because agglomeration is negligible as compared with the hydration of the sericin micelles. The setting temperature of these gels is indefinite. Sericin from cocoons having good "kaijo" gels more readily than that from cocoons having poor "kaijo." Gelatinization is easiest at the iso-electric point and occurs even in 0.1 per cent solutions on long standing. During gelatinization the pH generally rises for a few hours and then falls, after which syneresis becomes apparent. Heating gels to 60° C. causes sol formation but the gel will reform upon standing at room temperature.

Passing an electric current through sericin gels produces zones of precipitation which are accentuated by the presence of small amounts of magnesium chloride, aluminum chloride, ferrrous sulfate, lead nitrate, zinc nitrate, etc. Rhythmic precipitates (Liesegang's rings) are readily formed in sericin gels, but the order of velocity of diffusion of inorganic salts and of dyes in sericin gels is not quite the same as for agar or gelatin gels.

When sericin sols are heated to 100° C. over a period of time they exhibit a lowering in their viscosity and a decrease in their sensitiveness to electrolytes and their power to gelatinize. The cooling curves of sericin sols show a sudden change at about 50° C., probably due to the heat of gelatinization. The heat conductivity of the sols appears to be greater than that of the gels. The softening point of sols is higher when the "kaijo" is good than when it is poor.

When sericin sols are frozen at —6° C. for two hours and then allowed to stand overnight they separate into an insoluble fraction (Sericin A) and a soluble fraction (Sericin B). If the "kaijo" of the cocoons is good the Sericin A fraction will vary from 75.5 per cent to 79.2 per cent of the total. If the "kaijo" is poor the Sericin A fraction will be much less and will vary from 39.0 per cent to 42.6 per cent of the total. Undialyzed sericin depresses the freezing point in proportion to its concentration. The freezing point depression indicates a molecular weight of 9,000 to 15,000. Dialyzed sericin indicates a molecular weight of about 6,000.

X-ray analysis indicates that sericin has smaller main-axis components but more bulky side chains than fibroin. The molecular weight of the sericin micelles is estimated to be approximately 10,000.

The degree of hydrolysis of sericin has been determined by heating the aqueous solution of sericin under a reflux condenser with cupric chloride and sodium hydroxide, filtering, acidifying with acetic acid and titrating by the iodimetric method. The hydrolysis of sericin was more difficult when the "kaijo" of the cocoons was good than when it was bad. This is due to the fact that Sericin A is more resistant to alkali than Sericin B.

SERICIN A AND SERICIN B

The following brief summary of the properties of Sericin A and Sericin B as recorded in the recent literature will supplement the data given in Volume XXIII, 1934, Issue No. 9 of this journal:

Color: Sericin A is said to be gray and Sericin B white.

Solubility: Sericin A is less soluble than Sericin B in distinctly acid or alkaline solutions and the solubility of the former is more readily reduced by the action of heat or air. Both types are slightly more soluble in potassium hydroxide than in sodium hydroxide. With hydrochloric acid the minimum solubility for Sericin A is at pH 4.5 and for Sericin B at pH 4.7. With sulfuric the minimum solubility of A is at pH 4.4 and B at pH 4.6.

Buffer and Protective Action: The buffer capacity of both types of sericin approximates that of gelatin. Sericin A has a lower gold number and hence a higher colloidal protective power than Sericin B.

Specific Gravity: The apparent specific gravities of Sericin A and Sericin B in water are 1.356 and 1.309, respectively, as compared with 1.350 for raw silk. In various organic solvents A always has a higher specific gravity than B, the range for A being from 1.283 to 1.412 and for B from 1.265 to 1.339.

Reactions: Both Sericin A and Sericin B show the following reactions: Engle, Millon, Biuret, Mag and Rose, Neubauer and Rose, S, arginine, histidine and xanthopicric. With the Millon test B gives a deeper red than A. Both A and B when dissolved in dilute alkali show a slight yellow fluorescence in ultra-violet light. If a minute amount of glycocoll is added to the solution of B it gives a brilliant fluorescence. The solution of A is not affected in this manner.

Swelling: The addition of small amounts of sodium salts of organic acids increases the swelling in water of both Sericin A and Sericin B. With larger amounts of these salts there is a gradual falling off in the swelling. In general Sericin B swells more than Sericin A. With rising temperature an abrupt deviation occurs in the swelling curve at about 50° C., the point of transformation from gel to sol.

Absorption of Dyes: Sericin A has a stronger absorbing power for dyes (such as Acid Fuchsine, Congo Red and Methyl Violet) than Sericin B.

Heat: Sericin A is transformed gradually into Sericin B by heating it in a drying apparatus, by steaming it or by heating its solution in a flask. Hence, too high a heat in the drying of cocoons may transform A into B and lower the "kaijo" of the cocoons.

Iso-electric Points: The iso-electric point of Sericin A is now given as about pH 3.8, instead of pH 4.1 as previously reported. The iso-electric point of Sericin B is

now given as about pH 4.5 instead of pH 4.3 as previously reported.

THE COLORING MATTER OF SILK

A study has been made of the coloring matters of the green cocoons of *Bombyx mori var. Seihaku*. The cocoons were extracted with 70 per cent ethyl alcohol, the alcohol solution was evaporated to dryness and the residue was extracted with ether. A substance which gave flavone reactions was found in the ether extract. A yellow pigment was isolated in the ether insoluble part. This pigment was slightly soluble in water, quite soluble in acid and alkali but insoluble in ether and 95 per cent alcohol. It was decomposed at over 300° C. It was named as bombycin. It was hydrolyzed, by heating with a 5 per cent solution of sulfuric acid, into 1 molecule of glucose and 1 molecule of a glucone, called bombycetin.

The coloring matter of mulberry leaves was also extracted with alcohol as described above. An ether insoluble glucoside was isolated in a quantity equivalent to about 0.05 per cent based on the air-dried leaves. This glucoside proved to be isoquercitrin which had previously been isolated from maize. It was hydrolyzed by 5 per cent sulfuric acid into 1 molecule of glucose and one molecule of quercitrin.

THE CHEMISTRY OF FIBROIN

According to a recent study of Chinese silk, the percentage of fibroin in gray silk is higher than in white or yellow silk. The gray silk fibroin is more resistant than the other types of fibroin to hydrolysis with dilute hydrochloric acid or sodium hydroxide. The fibroin of white and of yellow silk is slightly hydrolyzed by the enzyme trypsin but not by pepsin, papain or erepsin.

Additional studies of the hydrolysis of silk fibroin have been published in American journals. Both acid and alkaline hydrolyses have been studied in the light of variations in the nitrogen content, the weight and the wet breaking strength of the fibroin so treated. For example, degummed silk was treated for ten hours with sodium hydroxide solutions ranging from 0 to 0.5 Normal at 25° C. and 40° C. and with hydrochloric acid solutions ranging from 0 to 2.0 Normal at 40° C. At this latter temperature, 0.5 N. sodium hydroxide and 2.0 N. hydrochloric acid had practically the same effect upon the nitrogen content and the weight of the fibroin. The wet breaking strength was decreased 50 per cent by 0.03 N. sodium hydroxide and by 0.9 N. hydrochloric acid.

The nitrogen content and the weight of fibroin have been shown to decrease very similarly during hydrolysis and to be logarithmic functions of the concentration of the hydrolytic agent. The quantitative data on hydrolysis, some of which were presented in the preceding paragraph, emphasized the following points: (1) the greater effect of alkali as compared with acid, (2) the greater effect on the wet breaking strength as compared with the loss in weight and nitrogen content and (3) the greater resistance to acid or alkali of wild silk fibroin as compared with the ordinary silk fibroin.

SOLUTIONS OF FIBROIN

As stated in the previous review, fibroin may be regenerated without substantial degradation from its solutions in the following agents: (1) alkaline solutions of copper hydroxide, (2) alkaline solutions of other metallic hydroxides, (3) concentrated solutions of sodium or calcium thiocyanate, (4) concentrated solutions of various halides or nitrates, (5) strong phosphoric or sulfuric acid at low temperatures and (6) liquid ammonia at about minus 77° C.

In a recent study it has been shown that fibroin dissolves slowly but practically completely in copper hydroxide in excess in the presence of alkali. A saturated solution of cupric hydroxide dissolves an average of 0.3217 gm. of fibroin for every atom of copper (0.064 gm.). If added soon after the solution of the fibroin, acids will reprecipitate the fibroin practically quantitatively but the longer the addition of acid is delayed, the smaller is the amount of fibroin reprecipitated.

Fibroin has been dissolved by copper hydroxide in excess in the presence of a dilute solution of barium hydroxide. After removal of the copper and the barium by precipitation and filtration, the filtrate was evaporated to dryness to obtain a pale yellow water-soluble product representing 92.5 per cent of the original fibroin. This product had a somewhat different nitrogen to carbon ratio than the original fibroin and it could be separated into two fractions with boiling methanol, both of which gave the Biuret reaction but differed appreciably in composition.

A comparison has been made of the acid-base titration curves, the iso-electric points and the specific rotations of a number of solutions of fibroin in various media such as concentrated solutions of lithium bromide, resorcinol and acid or alkaline solutions of glycerol with copper sulfate. The amide and the amino nitrogen contents of the fibroin regenerated from the above solutions were also compared.

The following conclusions were reached: (1) regenerated fibroin obtained from any of the above solutions had essentially the same chemical characteristics as the original fibroin, (2) fibroin was more easily dispergated in the above solutions if it was first exposed to the action of steam at temperatures as high as 130° C., (3) in the regeneration of fibroin from its solutions any decomposition products of the fibroin tended to remain dispersed in the solution unless the coagulation was very thorough, (4) the titration curve for silk fibroin showed a large base-combining power compared to the acid combining power and (5) the electrometric titration curves indicated an iso-electric point of about pH 3.2 for the silk fibroin of Italian yellow silk. This figure for the iso-electric point was higher than the figure of pH 2.5 previously assigned to fibroin by Milton Harris as a result of his study of the migration of the fibroin particles in an electrical field.

COMMERCIAL REGENERATION OF FIBROIN

The manufacture of artificial threads from solutions of fibroin in liquid ammonia continue to receive attention in the patent literature. In one method of treatment a solution suitable for the spinning of threads is obtained by dissolving the fibroin in liquid ammonia, mixing the solution with water, and removing the ammonia by evaporation. In a modification of this method, the dilute fibroin solution is treated with a compound such as sodium thiocyanate to reduce the surface tension and then concentrated by heating to 30-40° C. in a current of air. The solution of the fibroin in liquid ammonia may be assisted by the addition of inorganic salts which are soluble in the liquid ammonia, such as potassium thiocyanate, magnesium nitrate or potassium nitrate.

A fibroin solution suitable for the manufacture of artificial threads has been obtained by adding urea to a saturated solution of sodium thiocyanate, heating the solution to about 70-75° C. and then adding silk waste with vigorous stirring while the solution is cooled to 30° C.

Artificial fibroin threads may be formed by dissolving natural silk in phosphoric acid and extruding the resulting viscous solution into a precipitating bath containing chloride, formate or lactate. Stretch may be imparted to the pre-coagulated thread as it leaves the coagulating bath.

ADDITIONAL PROPERTIES OF SILK

The coefficient of thermal expansion of dry silk has been determined to be -7×10^{-6} at 100-130° C. At a relative humidity of 14.6 per cent the coefficient of thermal expansion of silk ranges from $(-0.5$ to $-9) \times 10^{-6}$ between 0° C. and 40° C.

The transverse electrical resistance of silk yarns and fabrics has been studied. The effects of varying the humidity, the voltage and the time of applying the voltage have been shown, as well as the effect of electrolytes normally present. The iso-electric point of silk, as determined by its electrical resistance, was reported to be near a pH of 4.2.

Chapter II

The Soaking of Silk

The first review of this series (issue of May 7, 1934) called attention to the controversy concerning the advantages and the disadvantages of the use of sulfonated mineral oils in the soaking of silk. Recently particular emphasis has been given to the advantages of mineral oil sulfonates for the soaking of silk which is to be used in the knitting of full-fashioned hosiery.

It is claimed that one of the chief causes of the pitting of the needles, sinkers and bits used in the knitting machines is the free fatty acid carried by the silk which was soaked in the usual emulsion containing animal or vegetable oils. The mineral oil sulfonates which are now available have the advantages of stability and freedom from the development of rancidity, they are excellent emulsifying agents and are soluble in water as well as in oils, fats, waxes and organic solvents.

The newer fatty alcohol sulfates are also excellent emulsifying agents. A recently patented formula for the soaking of raw silk comprises an oil-in-water emulsion containing a water-soluble sulfate salt of a higher fatty alcohol, such as the sodium salts of sulfate derivatives of hydrogenated cocoanut oil and lauryl alcohol.

Chapter III

The Degumming of Silk

The year 1935 witnessed the publication of a new method by Trotman and Bell which could be applied to the determination of the completeness of the removal of sericin from silk and to the detection of any appreciable deterioration of the silk during the degumming operation. This method consisted in determining the viscosity of a solution of the silk in an aqueous solution of zinc chloride under definitely prescribed conditions of temperature and time.

The following table gives the comparative viscosities in centipoises of solutions of Italian, Chinese and Japanese silk before and after degumming:

	Viscosity at 20° C.	
Type of Silk	*Gum Silk (centipoises)*	*Degummed Silk (centipoises)*
Italian	21.8	20.7
Chinese	22.8	19.0
Japanese	24.3	19.7

If the viscosity of the degummed silk solution is greater than 21.0 it would indicate that the removal of gum was not complete. On the other hand, if the viscosity is less than 19.0 it would indicate that the silk had been somewhat damaged in the process of degumming. It is claimed that any unusual deterioration of the silk by the action of acids, alkalis or peroxide bleaches can be detected in the same manner.

Another method of checking the efficiency of the boil-off of silk has been proposed by Denham and Dickinson. They have experimented with various stains designed to distinguish between sericin and fibroin and thus to detect the presence of residual gum on degummed silk. Satisfactory dyes for this purpose are Benzopurpurin 4BS, Purpurin 10BS, Diamine Green G and Acid Magenta N. The beads in gassed silk stain the same color as the gum and calcium soaps are usually stained, but it is thought that neither of these effects are likely to cause confusion.

The repeated use of the same soap solution for the degumming of successive lots of silks was discussed in the first review of this series published in 1934 and reference was made to the first article on this subject by the writer in 1925. The degumming baths have commonly been revived by controlled additions of alkali to bring the pH back to that of the original soap solution. Recently it has been proposed to improve this procedure by the regeneration of active soaps from such lime and magnesium soaps as may have formed during the boil-off. The phosphoboric esters of aliphatic alcohol sulfates are suggested as effective regenerating and dispersing agents.

A patented process for degumming natural silk in mixtures with cellulose acetate consists in treating the mixed fabric in the cold for ten minutes in a bath containing 20 gm. of sodium carbonate and 20 gm. of sodium isopropylnaphthalene sulfonate per liter, then diluting the bath with nine times its volume of water, adding soap and treating the goods for one hour at 80° C.

Chapter IV

The Weighting of Silk

Further light was thrown upon the mechanism of the adsorption of tin by silk in an extensive series of experiments, the results of which were published in the early part of 1935. Of the series of stannic chloride solutions used in this study, the optimum concentration for weighting was found to be 1.275 specific gravity. With a solution of this concentration, silk retained a maximum of 10.57 per cent of total weighting or 8.35 per cent of stannic oxide as shown by analysis. The retention of weighting by silk from stannic chloride solutions of lower concentrations was said to be a positive adsorption; from solutions of higher concentration, a negative adsorption.

Another article, in the nature of a review, points out that tannin-weighted silk is more durable than metal-weighted silk, but the former turns black in the presence of iron compounds and may turn brown if alkalies are present in the air. Any change in color of tannin-weighted silk after cleaning may be prevented by a final treatment in dilute lactic acid.

The patent literature contains further modifications of the Clavel weighting process which was described in detail in the first review of this series (issue of June 4, 1934). In the latest procedure the silk fabric was immersed in a 1 per cent solution of phosphoric acid which contained the desired amount of stannic chloride. It was then passed through squeeze rolls and without rinsing, immersed in a bath of monosodium phosphate and then in a bath of disodium phosphate. The dried fabric was finally immersed in a solution of sodium silicate which also contained a little soap.

Another method of swelling the silk fiber to increase its adsorption of tin was described in a Russian patent. The silk was treated at 70 to 80° C. with a solution of calcium chloride, passed through squeeze rolls and then exposed to the air to swell the fiber. The swollen silk was thoroughly rinsed and then weighted with tin in the usual manner.

Additional attention has been paid to the substitution of zinc and lead for tin as weighting agents for silk. Fabrics, partially weighted with tin, may be further weighted by treating them in a solution of an organic zinc salt, such as zinc acetate, and then with sodium phosphate. The zinc acetate may be present in a buffer solution and the silk fabric may subsequently be treated in a solution of sodium silicate. A basic solution of lead acetate may be used in a similar manner to the zinc acetate for the weighting of silk.

Chapter V

The Dyeing and Finishing of Silk

MORDANTING

A study of the mordanting of silk with chrome alum indicated that from a chrome-alum bath more chrome oxide (Cr_2O_3) then sulfur trioxide (SO_3) was absorbed by the silk. Repeated treatments of silk in a chrome-alum bath increased its acidity. The concentration of chrome alum in the solution had little effect upon the amount of chrome oxide absorbed by the silk. A bath containing 60 per cent of chrome alum could be used 2 to 3 times and an 80 per cent bath four times without the addition of further reagent. The mordanting efficiency of the bath could be restored by adding alkali to overcome the increasing acidity.

BLEACHING

The bleaching of plushes and velvets containing mixtures of silk and rayon has been described. The bath most commonly used for this purpose contains hydrogen peroxide mixed with a little ammonia or sodium silicate. The temperature of the bath is brought gradually up to 40° C. but preferably not any higher. Alternatively, sulfur dioxide or sodium bisulfite may be used, in which case there is no danger of saponification if the rayon happens to be cellulose acetate. Sodium hydrosulfite may be used to bleach tussah silks.

DYEING

Recent studies in the dyeing of natural silk have dealt with the effect of the pH of the dyebath and of the addition of sodium sulfate upon the dyeing of silk with direct dyes. Dialized Diamine Blue FF was used in a 5 per cent solution and the dyeings were continued for one hour at 50° C. and at 80° C. with a silk to dyebath ratio of 1:30 and 1:50. The pH values of the dyebaths ranged from 0.5 to 6.25 and they were determined at the start and at the end of each experiment. It was found that direct dyes are taken up by the protein substance of metallic-weighted silk to a lesser degree than acid dyes. This happened either because there were no secondary valencies of the protein substance available, these having been saturated by the weighting agent, or because the direct dyes, being less finely dispersed than acid dyes, are prevented from diffusing through the fibers by the weighting agent.

In strongly acid baths below pH 3.5 there appears to be an interaction between direct dyes and the weighting agent, causing a greater amount of dye absorption than with acid dyes which do not react. The dyeing of uniform shades in strongly acid dyebaths, therefore depends upon the even distribution of the weighting agent. On the other hand, in neutral or nearly neutral baths the dependence of the dye absorption upon the pH value of the baths indicates that uneven dyeing of weighted silk fabrics is caused by local differences in the pH values of the various sections of the silk.

The processes occurring during the dyeing of protein fibers, such as silk, have been explained by Elöd as follows: After diffusion into the fiber the colorless acid of the dye solution forms a protein salt, thereby causing a distribution

of the diffusible ions between fiber and dye solution which becomes decisive for the distribution of the dye anions between the dye solution and the fiber. The further absorption of dye is made possible by (1) the formation of an insoluble compound between fiber and dye solution, thus disturbing the membrane equilibrium; (2) a change in the degree of dispersion of the dye within the fiber, thus lowering the diffusibility of the dye or (3) the formation of very soluble, highly dissociated compounds between the protein fiber and the dye acids.

The reasons for two-tone dyeing in silk fabrics have been investigated. Definite evidence has been obtained that one of the important causes of this two-tone dyeing lies in the differences between the average diameter ratios of the silk filaments in two adjoining sections of the same fabric. By diameter ratio is meant the ratio of the smallest to the largest diameter of a given cross-section. When this average difference exceeds 0.04, two-tone dyeing becomes noticeable and it becomes extreme when the difference exceeds 0.12. To determine this difference with the desired accuracy of 1 per cent in the average value, at least 100 filaments must be measured. It is suggested that an auxiliary method of grading raw silk might be developed on the basis of diameter ratio.

The importance of fast color dyeing has been emphasized in several articles and patents. A new class of black dyes suitable for dyeing silk are increased in fastness by development with 2, 3-hydroxynaphthoic acid. A range of azo colors may be applied on silk by a process in which the color is developed by a reduction in the alkalinity of the dye paste. In this case, an amine salt such as dimethylamine chloride or an amide of a lower aliphatic acid such as oxamide are recommended for the development of the color.

Certain textile photochemical studies have indicated that the silk fiber behaves differently than cellulose fibers toward those naphthylamine- and amidonaphthol-sulfonic acids which are sensitive to ultra-violet light. Out of the 19 sulfonic acids which were studied, only 5 were found which yielded photo-oxidation products that could be developed with diazonium salts, or which undeveloped would give good Uviol matchings on raw silk. Specific directions were given for pattern-like matchings and the photographic reproduction of half-tones on silk.

PRINTING

A communication to a German textile magazine states that certain acid and direct dyes are capable of being fixed on silk by a short steaming of only 10 minutes' duration. Suitable acid dyes for this purpose are the Supramines, Supranol Orange RR, Anthosine BN, Acid Violet 4B Ex., Brilliant Indocyanine G and Alphanol Brown R. The direct dyes are of less importance because they do not produce as vivid colors as the acid dyes.

Certain alizarine derivatives, when printed on silk, have a tendency to yellow the white background in steaming. This may be prevented by chlorinating the silk prior to printing but it is not necessary to perform this chlorination if sodium bisulfite is added to the printing color.

Formulas for the printing of silk and rayon fabrics with chrome dyes have been given. A new chrome mordant developed by Durand and Huguenin is said to improve the fastness and the feel of fabrics colored with chrome dyes.

The cause of the tendering of tin-weighted silk during printing have been discussed. In order to locate the potential sources of this trouble it is necessary to examine critically all the steps in the processing of the silk from the cocoon stage to the finished print.

FINISHING

A patented method of preparing silk for use in electrical insulation consists in subjecting the degummed silk to washing baths under pressure in order to remove ionizable impurities. One bath, at least, should include a reagent such as acetic acid and the remaining baths may be simply pure water.

Special cockle or pebble effects are said to be produced in mixed fabrics containing silk and cellulose acetate by treating them with a solution of nitric acid which will shrink the cellulose acetate without materially shrinking the silk.

The finishing of printed silk fabrics has been reviewed with detailed descriptions of the various finishing operations. Printed silks are sufficiently different from piece-dyed silks in appearance and physical properties to require somewhat different treatments in the finishing room.

MISCELLANEOUS

The action of light rays of different wave lengths upon weighted and unweighted silk fabrics has been studied. The effects of the exposure were determined by comparisons of the tensile strengths before and after exposure. X-ray diffraction patterns of the unweighted silk made before and after exposure to the complete light source, appeared similar. However, photometric analysis indicated that the exposure of silk to light resulted in a decrease in fiber orientation causing the long fiber arc to expand toward the character of a powder pattern.

Silk has been recovered from knit goods in which the seam threads were composed of natural or synthetic cellulosic fibers (such as rayon), by treating the goods with warm hydrochloric acid vapor in order to quickly disintegrate the cellulosic fiber. The silk was then easily raveled out.

An analytical procedure has been developed for quantitatively removing silk from a mixture containing wool or cotton. The mixed fabric was agitated vigorously for one hour at 70° C. in a solution of calcium thiocyanate of specific gravity 1.20 to 1.21 which was made just acid to litmus with acetic acid. Precautions were taken to avoid the concentration of the solution by evaporation.

BIBLIOGRAPHY

NOTE: This bibliography deals primarily with the year 1935. However, certain articles of earlier dating are included as they were not reported in this country until 1935.

(Continued on page 475)

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AUGUST 24, 1936

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Standard Wash Fastness Samples

Cotton, Wool, Silk

The standard samples which have been in preparation for some time by the Sub-Committees on Fastness to Washing of Dyed Cotton and Dyed wool are now ready for distribution, and the original standard silk sample cards have been revised to correspond with the new system of classification first introduced in the 1934 Year Book.

These standards have all been carefully dyed with the dyestuffs and according to the dyeing methods recommended in the 1934 Year Book and each set includes a dyeing representing each of the different classes of fastness.

With these sample dyeings for reference it will be possible to accurately grade the fastness to washing of any dyed cotton, wool, or silk fabrics, by comparing them with the standards after subjection to the standard washing tests as approved by the Association.

The A.A.T.C.C. is now prepared to furnish these three sets of washing standards for $3.00 or $1.00 per individual set which is to cover the cost of preparation.

All inquiries concerning these washing standards should be addressed to the Chairman of the Research Committee.

LOUIS A. OLNEY,
LOWELL TEXTILE INSTITUTE,
LOWELL, MASSACHUSETTS.

A Study of the Mercerization Process

S. M. EDELSTEIN*

I.—The Effect of the Mercerizing Caustic Soda Concentration

INTRODUCTION

THE mercerization of cotton yarn and cloth is carried out mainly to increase the dye affinity, strength and luster of the material. The increase in one or all of these properties may be of particular importance to the mercerizer. There may also be secondary considerations of change in "handle", increase in evenness, elasticity and chemical reactivity of the material.

In the mercerizing process, the cotton yarn or cloth is immersed in a strong solution of caustic soda and if unrestrained will shrink. If the mercerized material is to have luster, the shrinkage must either be prevented or the yarn or fabric must be restretched before the caustic soda solution is washed out. In either case, a considerable force must be applied. After the caustic soda has been washed out of the material, the force may be removed. The material may then be neutralized with acid, washed and then processed in other ways or it may be finished and dried.

Although the literature on mercerization is extensive, the results of one worker cannot usually be related to that of another chiefly because such conditions as kind of cotton, yarn, caustic strength, tension, etc. are not the same. Also most workers usually have had only one or two particular factors or properties under study.[1, 2, 3, 4, 5, 6, 7]

The purpose of this investigation on the mercerization process is to determine the relationships that exist between the factors in the process and the properties of the resultant material.

In Part I of this investigation, the relationships that exist between the concentration of the mercerizing caustic soda and the properties of the mercerized cotton yarn have been studied under an arbitrarily chosen set of conditions. This set of conditions was carefully controlled.

The effect of varying the amount of shrinkage and stretch of the yarn during the mercerization and the properties of the mercerized yarn will be discussed in a future report. (Part II)

DISCUSSION OF RESULTS

In this work, a series of yarn samples were mercerized in caustic soda solutions of different strengths at a temperature of 80 degrees F. An arbitrarily chosen set of conditions was used in the preparation of the samples, but this set of conditions was held throughout. The yarn was held at the same constant length during the mercerization.

The force required to keep the yarn at the constant length during the treatment with each of the caustic solutions was determined and the finished samples were examined for luster, strength, moisture absorption, barium hydroxide absorption and dyeing properties. The shrinking of unrestrained skeins of yarn in the caustic soda solutions was also determined.

The results showed that as the concentration of the caustic soda solutions used for the mercerization increased, the force required to keep the yarn at the constant length in the caustic solution also increased. The luster of the finished samples was found to follow this increase with the sample mercerized in the strongest caustic solution showing the greatest luster. Since all samples were held at the same length during the mercerization, however, we cannot assume that the luster of each sample was the maximum luster that could be produced in that particular strength of caustic soda.

The properties of yarn strength, moisture absorption, equilibrium, dye absorption and barium hydroxide absorption did not increase in the same manner as did the force and the luster with the increase in caustic strength, but were found to increase rapidly up to a mercerizing concentration of 30 degrees Tw. After this concentration had been reached, there was very little increase or decrease in them.

In a previous paper[8], the barium activity number determination was described as a test for the presence of mercerization in cotton. The results of this work show that this determination can only indicate whether a sample of cotton has been mercerized or not and cannot be used to distinguish between samples of cotton mercerized at different strengths above 30 degrees Tw.

In equilibrium dyeings with three different direct dyes in which small samples of the mercerized yarns were allowed to come to equilibrium with a very large volume of dyebath, it was found that the amount of dye absorbed increased with the increase in the concentration of the caustic soda used for mercerizing up to 30 degrees Tw. after which the dye absorption remained the same. In certain exhaust dyeings, however, in which the rate of dye absorption becomes important, it was found that the samples mercerized in the caustic solutions stronger than 30 degrees Tw. did not absorb the dye at the same rate,

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the greatest rate of absorption being shown by those samples mercerized between 50 degrees Tw. and 65 degrees Tw.

EXPERIMENTAL WORK

I. Preparation of Mercerized Samples

A lot of 40/2, 1⅛ inch Mississippi Delta cotton of balanced twist, having an average of 13 turns per inch in the ply yarn was used for the preparation of the samples. This yarn was reeled into 1 ounce skeins of uniform 54 inch circumference and was mercerized in this form.

All of the yarn was treated in the same manner with the exception that various concentrations of caustic soda solutions were used. Sixteen 1 ounce samples were prepared at each of 14 caustic concentrations which ranged from 0 degree to 80 degrees Tw.

The following procedure was used in the preparation of the samples:

Sixteen 1 ounce skeins were wet out for thirty minutes at 175 degrees F. in three gallons of water containing 1 per cent of 50 per cent sulfonated castor oil. The yarn was rinsed twice in two three-gallon changes of warm water (100 degrees F.) and then carefully squeezed.

Each skein was individually mercerized on an experimental machine which allowed the skein to revolve around two rollers in a solution of caustic soda or in wash water. After the skein had been placed around the rollers, the distance between the two rollers was carefully adjusted so that the circumference of the skein would be held at 54 inches. This distance between the rollers was kept the same during the immersion in the caustic and during the washing out of the caustic.

After adjustment of the rollers, the skein was revolved slowly for five minutes in four gallons of the caustic solution at 80 degrees F. The bath of caustic solution was then removed and after allowing two minutes for drainage, the skein was revolved slowly for five minutes in four gallons of water at 140 degrees F. and then removed from the machine. This process was repeated until the sixteen skeins had been treated in the above manner.

The caustic solution was kept at a constant specific gravity for each set of samples by testing the specific gravity after each skein had been treated and adding the required amount of caustic soda to replace that removed by the yarn. The caustic soda solution for each set of samples was prepared fresh from flake caustic and the solutions never contained more than 0.2 per cent sodium carbonate.

After the sixteen skeins had been treated on the machine, they were neutralized together for ten minutes in four gallons of a 1 per cent sulfuric acid solution, washed in two three-gallon changes of 0.1 per cent ammonia solution, washed in three gallons of warm water, thoroughly squeezed and then carefully dried in an electric hot air dryer at a temperature of 165 degrees F. The finished skeins were each wound upon a paper cone, marked and wrapped in paper.

(Note: Zeolite water was used in the preparation of the mercerized samples.)

II. Measurement of Shrinkage and Force Required to Prevent Shrinkage

For the determination of the shrinkage and force measurements, skeins were prepared from the same yarn and in the same manner as those for the sample preparations, but each skein weighed 10 gms. instead of 1 ounce. These skeins were also wet out in a 1 per cent sulfonated castor oil solution in the same manner as the 1 ounce skeins.

A series of caustic soda solutions were prepared at a temperature of 80 degrees F. and a wet out 10 gm. skein was immersed in each solution. After five minutes the skeins were removed and the length of each determined under a tension of 50 gms. The skeins were then washed thoroughly in water at 140 degrees F. and measured again.

The results are given in Table I and plotted in Figure I as 100 times the ratio of the length of the original skein to that of the sample length. It is to be noted that in the caustic soda there is a rapid increase in shrinkage up to 35 degrees Tw. after which there is a decrease, whereas after washing out the caustic the resultant shrinkage on the samples treated in caustic solution above 30 degrees Tw. is closely the same.

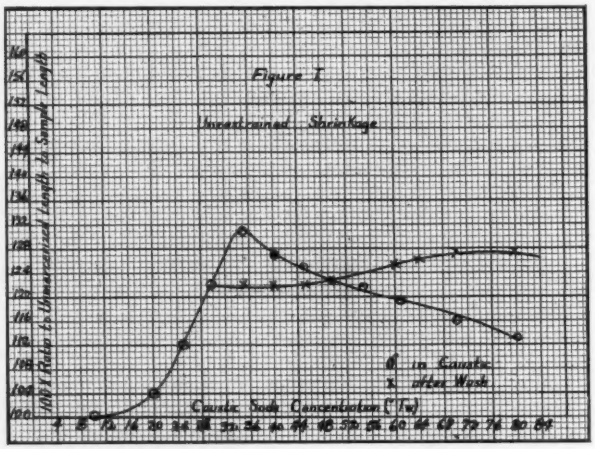
TABLE I

Shrinkage of 10 gm. skeins of 40/2 cotton yarn in caustic solutions and in caustic wash. Results are expressed as 100 times ratio of original skein length to length of sample skein.

Caustic concentrations in degrees Tw.	*Shrinkage (as expressed above) after caustic immersion*	*Shrinkage after caustic immersion and wash at 140 degrees F.*
0	100	100
10	100	100
20	104	104
25	112	112
30	122	122
35	131	122
40	127	122
45	125	122
50	124	123
55	122	123
60	122	125
65	118	126
70	116	127
80	113	127

In determining the force necessary to prevent the skeins from shrinking in the caustic soda solutions, the following procedure was used for each solution:

A 10 gm. skein was placed on the experimental mercerizing machine, the rollers adjusted to the same position



and the yarn was revolved in the solution in the same manner as in the treatment of the 1 ounce skeins. The top roller of the machine was fixed to one end of a pivoted beam on which a sliding weight could be moved until the pull of the yarn was exactly counterbalanced. The force exerted on the yarn was then read from graduations on the beam. The results which are given in Table II and plotted in Figure II show that as the caustic concentration is increased, the force required to prevent yarn from shrinking also increases.

III. Tensile strength and moisture regain of mercerized samples.

The tensile strength and moisture regain of the mercerized samples were determined after the samples had been allowed to condition for twenty-four hours under standard conditions of temperature and humidity. The results given in Table III and plotted in Figures III and IV show that the strength and moisture regain rises rapidly up to a mercerizing caustic concentration of 30 degrees Tw., after which the moisture regain remains constant and the tensile strength changes only slightly.

TABLE II

Force required to prevent 10 gm. 54 inch skeins of 40/2 cotton yarn from shrinking in caustic solutions of various concentrations. Temperature of solutions equals 80 degrees F.

Caustic concentration in degrees Tw.	*Force in lbs. required to prevent shrinkage*
0	
10.3	
15.0	
21.8	2.5
25.5	15
30.5	22.5
35.5	24
39	25
45	27.5
52.5	32.5
55.5	37.5
60	40
65	40
70	42.5
80	42.5

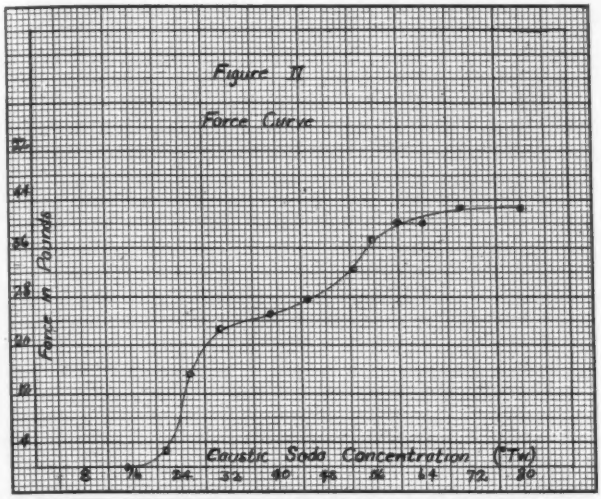
IV. Luster of the Mercerized Samples

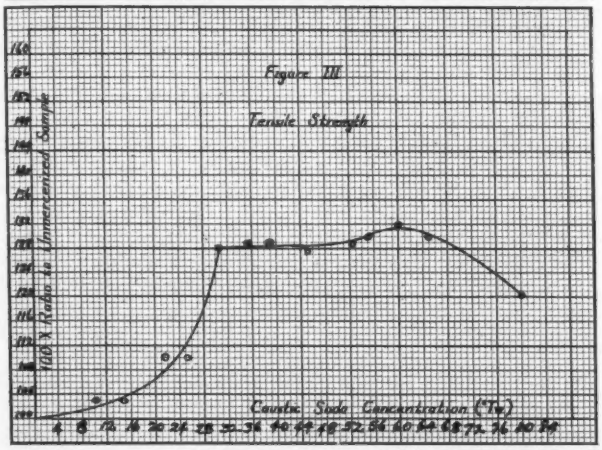
The samples were examined for luster in a qualitative way and the luster was found to increase as the mercerizing caustic concentration was raised. The samples mercerized in 10 degrees Tw., 16 degrees Tw. and 21.8 degrees Tw. showed no noticeable increase in luster over the untreated sample. The sample mercerized in 25.5 degrees Tw. showed the first noticeable amount of increase in luster over the unmercerized sample and those mercerized in 30 degrees Tw. and 35.5 degrees Tw. showed still larger increases. The luster of the samples mercerized in stronger caustic soda solutions increased steadily up to the final sample which was mercerized in 80 degrees Tw. caustic.

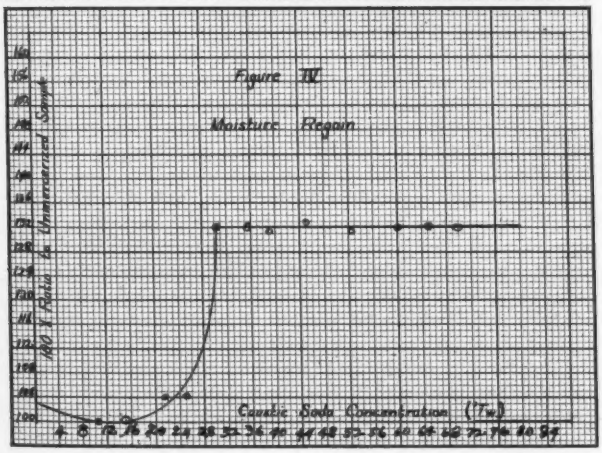
TABLE III

Tensile strength and moisture regain of mercerized samples. Tensile strength results are an average of three determinations made on 120 yard skeins with a Scott yarn tester. Tests were carried on at Alabama Polytechnic Institute at standard humidity and temperature.

Caustic conc. in degrees Tw.	*Tensile strength*	*100 x ratio to unmerc. value*	*Moisture regain*	*100 x ratio to unmerc. value*
0	122 lbs.	100	7.4%	103
10.3	126	103	7.2	100
15	125	103	7.2	100
21.8	134	110	7.5	104
25.5	134	110	7.5	104
30.5	156	128	9.5	132
35.5	157	129	9.5	132
39	157	129	9.4	131
45	155	127	9.6	133
52.6	157	129	9.4	131
55.6	159	130	9.5	132
60	161	132	9.5	132
65	159	130	9.5	132
70	153	125	9.5	132
80	146	120	9.4	130







More complete data on the quantitative measurements of the luster of the samples will be given in a future paper.

V. Barium Activity Number of the Samples

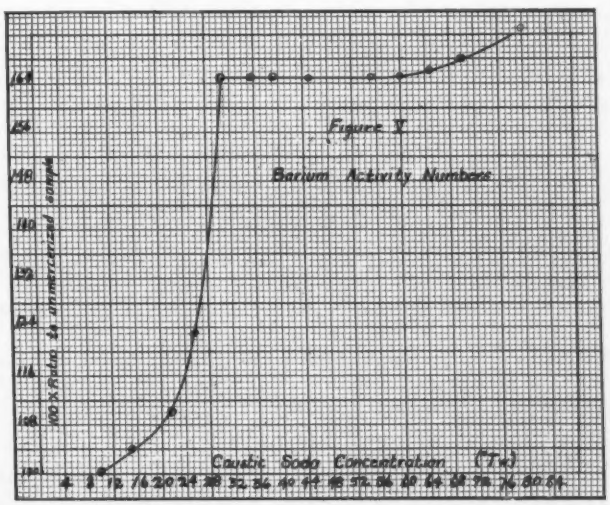
The barium activity numbers of the samples were determined by the method described in a previous paper.[8] This method consists of treating two gms. of the scoured sample with 30 cc. of 0.25N. barium hydroxide, allowing the sample to stand several hours and then determining the amount of barium hydroxide absorbed by the sample. The barium activity number is a measure of the amount of hydroxide absorbed by the sample.

The barium activity numbers of the samples increase rapidly with the increase in the mercerizing caustic concentration up to 30 degrees Tw. after which there is little change in the activity number.

TABLE IV

Barium activity numbers of the mercerized samples

Mercerizing caustic conc. in degrees Tw.	*Barium activity number*
0	100
10.3	100
15	104
21.8	110
25.5	123
30.5	165
35.5	165
39	165
45	165
52.6	165
55.6	165
60	165
65	166
70	168
80	173



VI. Dyeing Studies on the Mercerized samples

For the study of the dyeing properties of the mercerized samples, the following direct dyes were chosen: Chrysophenine G, Colour Index No. 365; Sky Blue FF, Colour Index No. 518 and Benzopurpurine 4B, Colour Index No. 448.

These three dyes were chosen because they represent

direct dyes which differ widely in dyeing properties—Sky Blue FF and Benzopurpurine 4B being dyes of high affinity and poor levelling power while Chrysophenine G has a low affinity and excellent levelling properties. These dyes have also been used successfully in similar dyeing studies by other workers.[9, 10]

a. Purification of the Dyes.

The dyes were obtained from the manufacturer in the concentrated form and were purified as follows:

The dye was dissolved in a minimum amount of boiling water and then a saturated solution of sodium acetate was added to precipitate the dye. The precipitated dye was separated from the liquor by centrifuging, washed several times, redissolved in boiling water and the whole process of precipitation, centrifuging and washing repeated. This was done five times and the dye was then washed several times with boiling absolute alcohol and finally dried at 105 degrees C.

b. Nature of the Dyeing Studies.

The studies on the direct dye absorption of the mercerized samples were divided into three types as follows:

(1) Equilibrium dyeings in which small samples were allowed to come to equilibrium with a very large volume of dyebath so that the amount of dye absorbed by the samples did not materially change the dye concentration of the bath.

(2) Rate of absorption determinations in which the amount of dye absorbed by each sample after a definite time in the dyebath was determined. (Only carried out on Sky Blue FF).

(3) Exhaust dyeings in which the volume of the dye solution was such that most of the dye was removed from the bath by the samples.

In all of the dyeings, the samples were dyed together in the same bath, 100 mg. of each sample being used. Previous to dyeing the set of samples was scoured for one-half hour in a solution containing 1 per cent olive oil soap and 0.2 per cent soda ash and then thoroughly rinsed and dried.

For the equilibrium dyeings, a four liter flask fitted with a reflux condenser was used. The flask was set in a glycerine bath, the temperature of which was controlled by a gas flame. The exhaust dyeings were carried out using 100 mg. samples in an open beaker which was also heated in the glycerine bath. After the samples had been dyed, they were immediately rinsed in cold water, squeezed on filter paper and dried. Distilled water was used in all of the dyeings.

c. Determination of Dye on Samples.

The amount of dye present on each sample after the dyeing was determined as follows:[11]

50 mg. of the dyed sample was accurately weighed out and placed in an 150 cc. Erlenmeyer flask. 25 cc. of pyridine solution (one part pyridine to three parts water) were added to the flask which was then stoppered and allowed to stand several hours with frequent shaking. After standing, the color was completely extracted from the sample by the pyridine solution. This solution was then placed in a Duboscq colorimeter and by comparison with a freshly made standard dye solution, the amount of dye extracted from the sample was thus determined.

d. Equilibrium Dyeings.

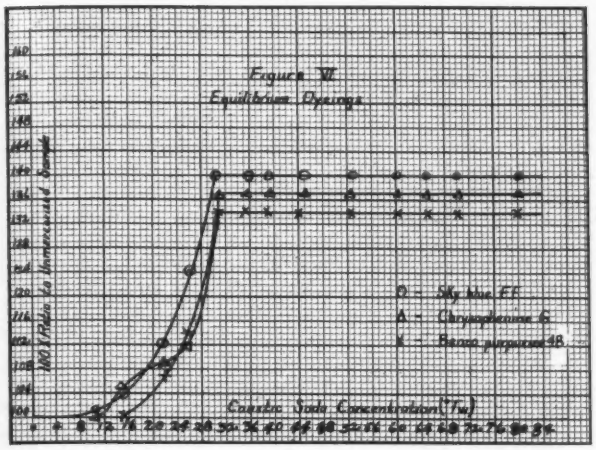
Equilibrium dyeings were made with the three dyestuffs at the boil using a series of fifteen 100 mg. samples in two liters of dye solution containing approximately 0.10 gms. of dye and 10 gms. of salt (sodium chloride). Samples of the bath were withdrawn from time to time and compared in the colorimeter with a standard in order to determine when the bath and samples had reached equilibrium. The results given in Table V and graphed in Figure VI show that at equilibrium, Benzopurpurine 4B is absorbed most, Sky Blue FF next and Chrysophenine G least. The shape of the absorption curves is closely the same for the three dyes with the maximum absorp-

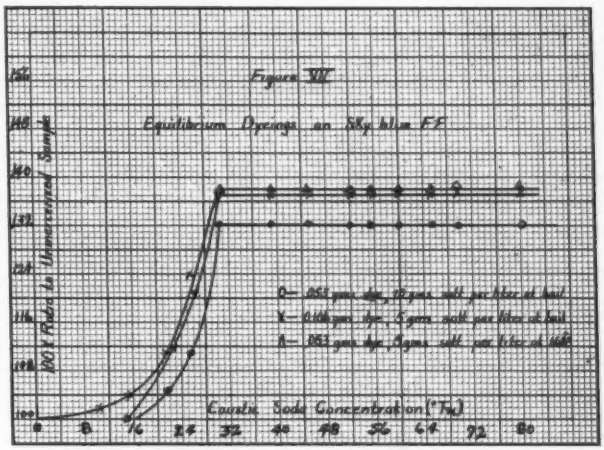
TABLE V

Equilibrium Dyeings At Boil

A equals per cent dye on weight of sample. B equals 100 times ratio of sample absorption to unmercerized absorption

	Benzopurpurine 4B		*Sky Blue FF*		*Chrysophenine G*	
Caustic conc.	*A*	*B*	*A*	*B*	*A*	*B*
0	0.57	100	0.36	100	0.21	100
10.3	0.57	100	0.36	101	0.21	100
15.0	0.57	100	0.37	104	0.22	105
21.8	0.61	107	0.40	112	0.23	109
25.5	0.65	114	0.45	124	0.24	112
30.5	0.76	134	0.50	140	0.29	137
35.5	0.76	134	0.50	140	0.29	137
39	0.76	134	0.50	140	0.29	137
45	0.76	134	0.50	140	0.29	137
52.6	0.76	134	0.50	140	0.29	137
55.6	0.76	134	0.50	140	0.29	137
60	0.76	134	0.50	140	0.29	137
65	0.76	134	0.50	140	0.29	137
70	0.76	134	0.50	140	0.29	137
80	0.76	134	0.50	140	0.29	137





tion being reached by the samples mercerized at 30 degrees Tw. and above.

The effect of dye concentration, salt concentration and temperature on the equilibrium absorptions of Sky Blue FF was determined in similar dyeing tests. Under the conditions studied, it was found that more dye was absorbed at the lower temperature and at the higher salt and dye concentration. The ratio between the amount absorbed by the samples and that absorbed by the unmercerized sample was lower at the greater dye concentration, but the shape of the absorption curves is closely the same with a maximum absorption by samples mercerized between 30 degrees and 80 degrees Tw. caustic concentration. See Table VI and Figure VII.

e. Rate of Absorption of Sky Blue FF.

In order to determine if there was any difference between the rate of reaching equilibrium for the different mercerized samples, the following dyeings were made with Sky Blue FF:

Three sets of 100 mg. samples were dyed at the boil in two liters of dyebath containing 0.10 gm. dye and 10 gms. of salt for thirty, ten and two minutes and the amounts of dye absorbed by the samples were determined.

Analysis of the samples showed that after thirty minutes all of the samples had reached equilibrium. After ten minutes those samples mercerized above 25 degrees Tw. had reached equilibrium while those mercerized below had not. After two minutes, none of the samples had reached equilibrium. These results which are given in Table VII and in Figure VIII also show that while the samples mercerized in solutions stronger than 30 degrees Tw. absorb the same amount of Sky Blue FF at equilibrium, the rate at which the dye is absorbed may be different between these samples.

Rate absorption determinations could not be carried out with accuracy on samples dyed for less than two minutes and so differences in absorption rates were next studied by means of exhaust dyeings.

TABLE VI

Equilibrium dyeings on Sky Blue FF. Fifteen 100 mg. samples in two liters of dyebath. A is equal to per cent of dye on weight of sample. B is equal to 100 times the ratio of sample absorption to unmercerized absorption

Caustic conc. Tw.	*.053 gms. dye, 10 gms. salt per liter At Boil*		*.106 gms. dye, 5 gms. salt per liter At Boil*		*.053 gms. dye, 5 gms. salt per liter At 160 degrees F.*	
	A	*B*	*A*	*B*	*A*	*B*
0	0.56	100	0.54	100	0.58	100
10.3	0.56	100	0.55	102	0.58	100
15	0.56	100	0.56	104	0.58	100
21.8	0.58	105	0.60	111	0.65	112
25.5	0.65	116	0.67	124	0.70	121
30.5	0.74	132	0.74	137	0.80	138
35.5	0.74	132	0.74	137	0.80	138
39	0.74	132	0.74	137	0.80	138
45	0.74	132	0.74	137	0.80	138
52.6	0.74	132	0.74	137	0.80	138
55.6	0.74	132	0.74	137	0.80	138
60	0.74	132	0.74	137	0.80	138
65	0.74	132	0.74	137	0.80	138
70	0.74	132	0.75	138	0.80	138
80	0.74	132	0.75	138	0.80	138

TABLE VII

A equals per cent dye on weight of sample. B equals 100 times ratio of sample absorption to unmercerized absorption

Dyeings at boil. 100 mg. samples in two liters of dyebath containing 0.05 gms. of dye and five gms. of salt per liter

Caustic conc. Tw.	*After 30 minutes*		*After 10 minutes*		*After 2 minutes*		*Equilibrium Absorption*	
	A	*B*	*A*	*B*	*A*	*B*	*A*	*B*
0	0.36	100	0.34	100	0.18	100	0.36	100
10.3	0.36	101	0.34	100	0.18	100	0.36	101
15	0.37	104	0.35	102	0.19	107	0.37	104
21.8	0.40	112	0.38	111	0.25	133	0.40	112
25.5	0.45	124	0.45	130	0.26	147	0.45	124
30.5	0.50	140	0.50	148	0.28	158	0.50	140
35.5	0.50	140	0.50	148	0.28	158	0.50	140
39	0.50	140	0.50	148	0.28	158	0.50	140
45	0.50	140	0.50	148	0.28	158	0.50	140
52.6	0.50	140	0.50	148	0.28	158	0.50	140
55.6	0.50	140	0.50	148	0.28	158	0.50	140
60	0.50	140	0.50	148	0.28	158	0.50	140
65	0.50	140	0.50	148	0.28	158	0.50	140
70	0.50	140	0.50	148	0.27	155	0.50	140
80	0.50	140	0.50	148	0.26	150	0.50	140

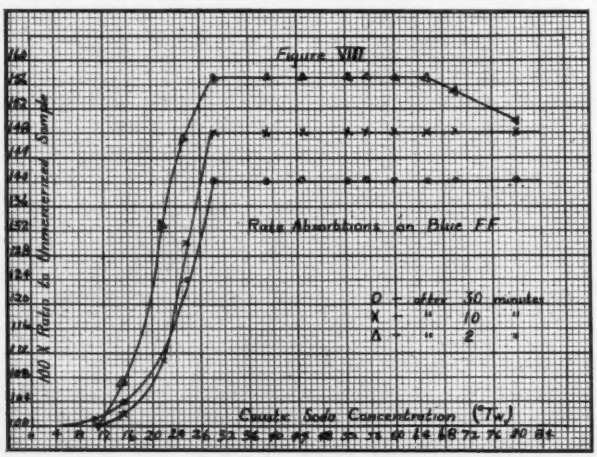


Figure VIII
Rate Absorbtions on Blue FF
O = after 30 minutes
X = " 10 "
Δ = " 2 "
100 x Ratio to Unmercerized Sample
Caustic Soda Concentration (°Tw)

f. Exhaust Dyeings.

Two exhaust dyeings were made with each dye at the boil. The first of these dyeings were made using an initial dyebath containing more dye than would have been absorbed by the set of samples if they had been allowed to come to equilibrium with such a dyebath kept at the same concentration. The second dyeing was made using an initial dyebath containing less dye than would be absorbed by the set of samples if they were allowed to come to equilibrium with such a constant dyebath.

From an examination of the results in Tables VIII, IX and X and Figures IX, X, and XI the following is to be noted:

(1) In the first type of exhaust dyeings for all three dyes, the absorption curves are the same in shape as the equilibrium absorption, all of the samples mercerized above 30 degrees Tw. absorbing the same amount of dye.

(2) In the second type of exhaust dyeing, the absorption curves differ from that of the equilibrium dyeings mainly in that the samples mercerized above 30 degrees Tw. take different amounts of dye with a maximum absorption by those samples mercerized between 50 degrees and 65 degrees Tw.

(3) Although the actual differences in dye absorption between the samples mercerized above 30 degrees Tw. in (2) are not very great, these differences are larger for Benzopurpurine 4B and Sky Blue FF than for Chrysophenine G.

(4) For a definite amount of dye to be absorbed by the samples in the exhaust dyeings, a much greater ratio of bath to sample must be used for the Sky Blue FF and the Benzopurpurine 4B than for the Chrysophenine G in order to have a solution giving a flat absorption curve for the samples mercerized above 30 degrees Tw.

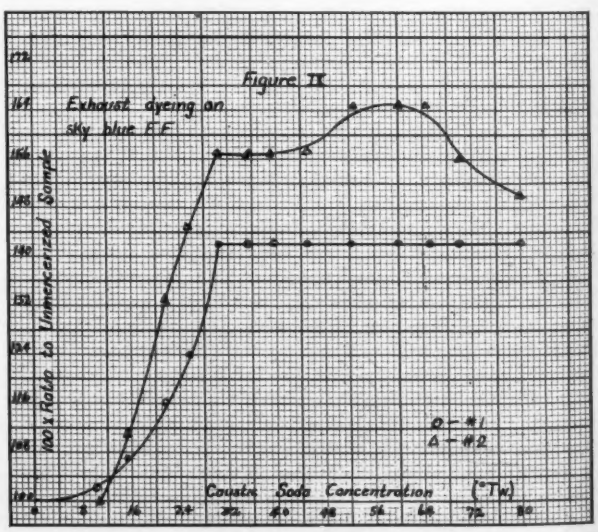


TABLE VIII

Exhaust dyeings on Sky Blue FF at boil (212 degrees F.)

Dyeing No. 1. 0.5% dye on weight of samples. Ratio of samples to bath equals 1 to 100. Concentration of dyebath equals 0.53 gms. dye and 5 gms. salt per liter of dyebath. Equilibrium absorption with the initial bath would be approximately 0.48% dye on weight of samples.

Dyeing No. 2. 0.42% dye on weight of samples. Ratio of samples to bath equals 1 to 30. Concentration of dyebath equals 0.12 gms. dye and 5 gms. salt per liter. Equilibrium absorption with initial bath would be approximately 0.72% dye on weight of samples.

Mercerizing caustic conc. in degrees Tw.	*100 x ratio of sample absorption to unmercerized absorption*	
	No. 1	No. 2
0	100	100
10.3	102	100
15	107	111
21.8	116	133
25.5	124	145
30.5	142	157
35.5	142	157
39	142	157
45	142	157
52.6	142	165
55.6	142	165
60	142	165
65	142	165
70	142	156
80	142	150

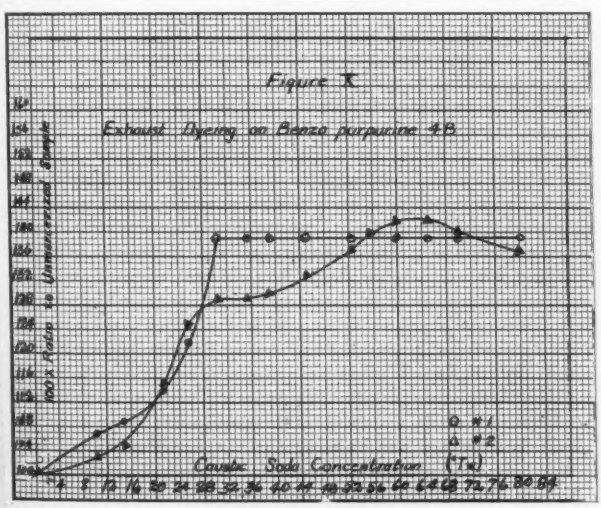
TABLE IX

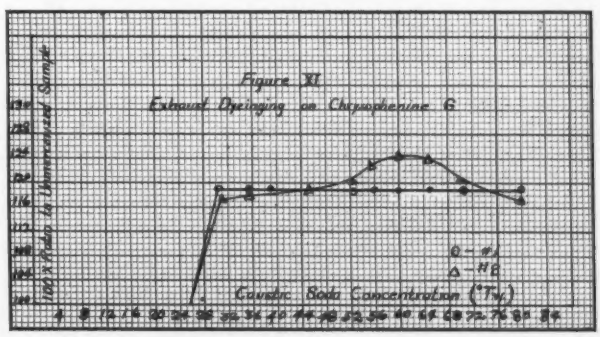
Exhaust dyeings on Benzopurpurine 4B at boil.

Dyeing No. 1. 1.2% dye on weight of samples. Ratio of sample to bath 1 to 200. Concentration of dyebath equals 0.055 gms. dye and 5 gms. salt per liter. Equilibrium absorption with the initial bath would be approximately 0.75% dye on weight of samples.

Dyeing No. 2. 0.6% dye on weight of samples. Ratio of samples to bath equals 1 to 100. Concentration of dyebath equals 0.055 gm. dye and 5 gms. salt per liter. Equilibrium absorption with the initial bath would be approximately 0.75% dye on weight of samples.

Mercerizing caustic conc. in degrees Tw.	*100 x ratio of sample absorption to unmercerized absorption*	
	No. 1	No. 2
0	100	100
10.3	107	103
15	109	105
21.8	114	115
25.5	122	125
30.5	139	129
35.5	139	129
39	139	130
45	139	133
52.6	139	137
55.6	139	140
60	139	142
65	139	142
70	139	140
80	139	137





SUMMARY

The relationships between the caustic soda concentrations and the properties of yarn mercerized in these solutions under a particular set of conditions have been studied.

The luster of the mercerized samples increased with an increase in caustic concentration up to 80 degrees Tw. The luster appeared to be related to the force exerted by the yarn when prevented from shrinking in the caustic soda solution.

The equilibrium dye absorption, moisture absorption, barium hydroxide absorption and tensile strength of the mercerized samples increased with the concentration of the caustic soda solution only up to a concentration of 30 degrees Tw. The samples mercerized above 30 degrees Tw. showed very little increase or decrease in these properties.

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TABLE X

Exhaust dyeings on Chrysophenine G at boil. (212 degrees F.)

Dyeing No. 1. 0.27% dye on weight of samples. Ratio of sample to bath equals 1 to 50. Concentration of dyebath equals 0.05 gm. dye and 5 gms. salt per liter of dyebath. Equilibrium absorption with the initial bath would be approximately 0.27% dye on weight of sample.

Dyeing No. 2. 0.27% dye on weight of samples. Ratio of sample to bath equals 1 to 25. Concentration of dyebath equals 0.10 gm. dye and 5 gms. salt per liter. Equilibrium absorption with the initial bath would be approximately 0.4% on weight of samples.

Mercerizing caustic conc. in degrees Tw.	*100 x ratio of sample absorption to unmercerized absorption*	
	No. 1	No. 2
0	100	100
10.3	100	100
15	100	100
21.8	100	100
25.5	100	100
30.5	119	118
35.5	119	118
39	119	119
45	119	119
52.6	119	120
55.6	119	123
60	119	124
65	119	124
70	119	120
80	119	117

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[11]S. M. Neale, Am. Dyestuff Reptr. *23*, 109, 1934.

TENTATIVE PROGRAM
for

ANNUAL MEETING AND CONVENTION

Friday A.M. — Registration and Sight-Seeing
Friday P.M. — 1:30 Council Meeting
2:30 Research Committee Meeting
Sight-Seeing
6:30 Buffet Supper
7:30 Technical Papers
9:30 Smoker
Saturday A.M. — 9:30 Technical Papers
12:00 Election of Officers
Annual Business Meeting
Saturday P.M. — 2:00 Technical Papers
7:30 Banquet
Speakers
Entertainment
Headquarters: Biltmore Hotel

Committees for ANNUAL MEETING AND CONVENTION

Providence, R. I., Dec. 4 and 5
Auspices, Rhode Island Section

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Franklin Process Co.

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Speakers

Ralph Culver, Chairman
Ciba Co.

UNEMPLOYMENT REGISTER

Members of this association, who are without employment, should forward to the secretary a statement as to their qualifications and experience. This information will subsequently appear on these pages with an identifying key number. Employers are also requested to file with the secretary any vacancies which may occur in their businesses.—H. C. Chapin, Secretary, Lowell Textile Institute, Lowell, Mass.

Key: A—Laboratory and research; B—Dyeing or printing; C—Finishing; D—Sales; E—Instruction; F—Executive.

NOTE: PERSONS WHO HAVE OBTAINED EMPLOYMENT SHOULD NOTIFY THE SECRETARY OR THE AMERICAN DYESTUFF REPORTER AT ONCE. Prospective employers may file vacancies either with the secretary or the American Dyestuff Reporter.

A-6

Education—Analytical Chemistry and Dyeing Course, Lowell Textile Evening School.

Experience—Seven years as print color and dye chemist in printing, dyeing and finishing plants; recently in charge of textile printing department of dyestuff manufacturer.

A-B-2

Education—Lowell Evening Textile School, 1917.

Experience—Five years' experience in hosiery dyeing, full fashioned hosiery of silk and cotton and silk, also men's hosiery containing rayon, wool, cotton and celanese. Several years experience in laboratory work. Has also had experience in jig-dyeing of cotton piece goods, slub and top dyeing.

A-B-4

Education—B.T.C. 1934, Lowell Textile Institute.

Experience—Assistant chemist in cotton knitting plant; second-hand in woolen knit goods dye house. Will go anywhere; references.

A-B-5

Education—Graduate of the University of Lausanne, Switzerland. Doctor's degree in Chemistry. Knowledge of French and German.

Experience—Eleven years with large bleaching, dyeing, printing and finishing plant as assistant Chemist and then Chemist in charge of the Laboratory. Experience in dyeing and printing cotton and rayon fabrics; research and analytical work. Woman.

A-B-7

Education—Evening school in textile dyeing.

Experience—2 years laboratory in dyehouse; 9 years dyer and foreman on hosiery, ribbons and rayon; 2 years assistant to superintendent. Can handle help efficiently. Desires position as supervisor or demonstrator of dyestuffs. Age 30; married. Prefers vicinity of New York.

A-B-C-2

Education—Graduate of Lewis Institute of Engineering of Chicago and graduate of Philadelphia Textile School (Chemistry and Dyeing department).

Experience—Has had extensive experience as assistant chemist and colorist in silk printing, dyeing and finishing; also dyeing raw stock wool; and dyeing and finishing cotton and rayon. Age 30; married; references.

A-B-C-3

Education—3 years at Brown University and Drexel Institute.

Experience—2½ years in dyestuff laboratory; 3 years as second-hand, dyeing indanthrene and direct colors on rayon skeins; 6 months as boss dyer on silk and cotton ribbons and hosiery; 3 years overseer of dyeing and finishing rayon tubing. Can handle laboratory, dyehouse, finishing or outside service. Age 30; married.

A-B-C-D-E-1

Education—B.S. Chemistry, Mass. Institute of Technology.

Experience—Plant and laboratory work. Knowledge of wool scouring; cotton, worsted, celanese and rayon slashing; bleaching, dyeing, printing and finishing of cotton cloth; printing of Plissé; manufacture of soaps, finishing compounds and wetting-out agents; analytical work; solution of mill manufacturing difficulties; dyestuffs and their application to wool, cotton, rayon; textile teaching experience; paper mill work; some sales experience; references; married; 43 years old.

A-B-C-F-1

Education — Five years chemistry and engineering, Brown University (Evenings).

Experience—1 year general superintendent at print works (shirtings, dress goods, etc.; cotton and rayon). 12 years chief chemist and superintendent of large bleachery and dyeworks (cotton, rayon and silk piece goods). 4 years chemist in charge of control work in bleach, print and dye works (cotton, wool and rayon piece goods). 9 years chief chemist and assistant superintendent in gas and oil manufacture. Practical dyer and finisher and can handle help efficiently and get results. Can help a plant seeking to improve their vat dyeing, shrinkage results, finishes and service to customers. Age 45; married.

A-C-1

Education—4 years at Newark Evening Technical School in Chemical Engineering.

Experience—8 years in manufacturing, research, testing of soaps, oils, gums and finishes and application of same in all phases of the textile industry. Age 23, single. References.

A-E-1

Education—Ph.D., Univ. of Illinois, studied chemical engineering at Columbia, licensed chemical engineer, New Jersey.

Experience—10 years' experience teaching in colleges, subjects included chemical and textile subjects. Has had broad experience in industrial work including experience in testing materials, research and consulting. Will go anywhere; references.

B-1

Education—Educated and trained in chemistry and calico printing in Glasgow, Scotland.

Experience—Has been with large print works as colorist for 13 years producing first class work on cotton, rayon, wool and silk fabrics. References.

B-2

Experience—Boss dyer with one firm for 18 years, divisional supt. at print works for 1 year, in charge of processing and dyeing of cottons and rayons at large bleachery for 6 years. Prefers bleachery in East but will go anywhere. References.

B-3

Experience—Foreman piece dyer for the past 21 years. Can dye the following: celanese, rayon, cotton backs, wool, silk and mixed fabrics. Has knowledge of finishing and laboratory work.

B-6

Education—Graduate R. I. School of Design.

Experience—5 years in bleachery, 7½ years as assistant dyer, 2 years as boss dyer and 3 years as superintendent of dyeing and finishing. Married, 33 years old. References.

B-7

Experience—Eight years as boss dyer on skeins and ribbons. Over ten years as chemist and head dyer for a large hosiery mill. Experienced on Silk, cotton, rayon and wool in skeins, ribbons, piece goods and all kinds of mixtures. Willing to go anywhere. Not afraid to work or face responsibility. Can handle help efficiently.

B-8

Education—Chemistry and Dyeing Department, Philadelphia Textile School.

Experience—Eleven years experience as chemist and boss dyer on the following: woolen, worsted and cotton yarn; woolen, worsted and union piece dyes on both ladies' and men's wear; wool, cotton, shoddy and mohair raw stock. Age 33, married, will go anywhere. References.

B-9

Experience—Hosiery dyer with fifteen years' experience on high grade silk hosiery; familiar with all types of machines. Age 43, married. Will go anywhere.

B-14

Education—Rhode Island School of Design.

Experience—Familiar with all classes of wool dyeing. Seven years with large carpet mill as dyer and processor of washed oriental rugs. Will go anywhere, married, 37 years old. References.

B-15

Education—B.T.C., Lowell Textile Institute, 1934.

Experience—Experience in dye house running washers, dye kettles and as a dye weighter.

B-17

Education—Lowell Textile Institute (Chemistry and Dyeing Course) 1916; extension courses at Brown University.

Experience—6 months dyeing wool at finishing company; 2½ years research work on bleaching, dyeing and finishing at dye works; inspector of textile equipment, U. S. Ordnance Dept., during war; 15 years as superintendent of dyeing at finishing company, including all types of colors on cotton piece goods and some rayon and celanese; handled chemical work at last named plant for many years as well as dyeing. Age 40, married, prefers East. References.

B-20

Education—Chemistry and Dyeing Dept., Philadelphia Textile School.

Experience—Thirteen years' experience as boss dyer on the following: rayon and cotton skein and piece goods and knitted fabrics. Raw stock dyeing in pressure dyeing machines. Age 35 years, married, can handle help efficiently.

AMERICAN
DYESTUFF
REPORTER

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Directing Editor

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CHEMICAL EXPORTS

THE position of the American chemical industry in the world market is steadily strengthening to judge by preliminary figures covering the export business during the first half of 1936. According to C. C. Concannon, Chief of the U. S. Commerce Department's Chemical Division, United States exports of chemicals and related products advanced 20 per cent during the first six months of 1936 with notable gains being recorded in foreign shipments of benzol, dyes, sulfur, fertilizers and a number of other products.

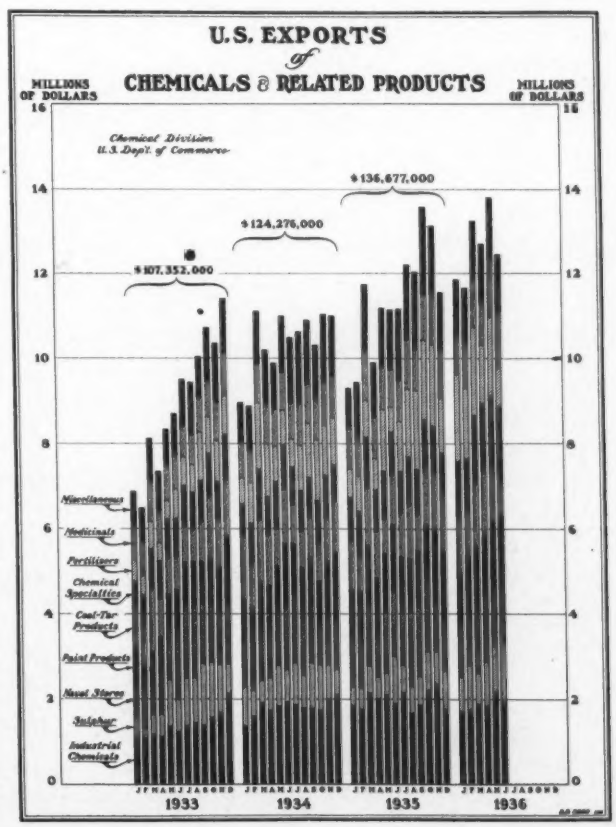
Exports of such products were valued at $75,733,000 during this period in 1936 as compared with $62,670,000 in the similar period of 1935 and $45,909,000 for the corresponding months of 1933. Foreign demand for all types of American fertilizers has been especially heavy since the beginning of the year with shipments to foreign countries aggregating 858,000 tons, valued at $9,801,000 corresponding to figures in the previous year of 560,356 tons valued at $5,100,000. Phosphate shipments increased from 452,575 to 649,600 tons; potashes from 33,085 to 47,891; and nitrogenous materials from 55,643 to 146,585, according to the preliminary figures.

In the chemical specialty group substantial export gains were also recorded. This was particularly the case with household and agricultural insecticides, petroleum jelly, rubber and textile compounds, cementing preparations and polishes. The value of this group of products increased from $6,384,000 in the first six months of 1935 to $9,455,000 in the corresponding period of this year. The export demand for sulfur since the beginning of 1936 has been the best in years according to the statistics available. Shipments of this product, both crude and refined totalled 295,000 tons, valued at $5,506,000, compared with 182,734 tons, valued at $3,607,000 in the first half of last year.

Coal tar products exports, particularly dyes, continued to increase attaining a value of $7,425,000, an increase of approximately $1,000,000 over the corresponding period of 1935. Shipments of dyes, colors, stains, etc., which are included in this group increased from 9,274,500 pounds to 11,168,000 pounds and benzol from 5,116,000 to 8,165,400 gallons.

Statistics regarding other chemical products showed that:— American paint products were sold to practically every country of the world during the first half of the year and shipments increased in value about a million dollars over the corresponding period in 1935 to $8,790,000; carbon black exports weakened somewhat due to smaller shipments to Germany; demand for naval stores increased; export demands for industrial chemicals remained about the same with substantial gains recorded for certain items in the group, for example, shipments of compressed, liquefied, and solidified gases increased about 50 per cent; crude drugs increased in value from $598,000 to $705,800, vegetable dyeing and tanning extracts from $889,675 to $1.017,000, medicinals from $5,810,000 to $6,768,000, toilet preparations from $2,125,300 to $2,549,000, soaps from $1,182,150 to $1,283,700 and printing inks from $403,300 to $476,775.

The above figures again serve to show that the chemical industry of this country is one of the most healthy and that it continues to thrive on a sound basis under intelligent management. In this industry it was not found necessary to "plough under" any of the products.



Latest Advances in

Pin Tenter Drying

B. M. JONES*

Of all the textile processes, tenter drying at present offers one of the greatest possibilities for increased efficiency and savings in a textile mill. Modern tenter equipment probably provides a larger return for the investment than any other single piece of textile machinery.

In order to show how this is possible, the fundamental principles of tenter drying are listed, and the manner in which these principles are applied in a modern machine are shown.

PRINCIPLES OF TENTER DRYING

1. The temperature in the dryer must not be so high that it will cause damage to the fabric nor so low that efficiency is impaired.
2. Drying must be uniform. That is, every fiber should become dry at a uniform rate of speed.
3. The temperature should be graduated so that the dryer is hottest at the feed end where the cloth is wet and the evaporation will cause a cooling effect. As the cloth becomes dryer, and the cooling effect of evaporation becomes less, the temperature should be less. Finally, at the delivery end of the dryer, the temperature should approach room temperature.
4. Proper circulation and uniform distribution of the heated air must be provided.
5. The proper humidity for most efficient operation must be maintained in the dryer.
6. Heat losses through radiation or leakage should be avoided.
7. Steam consumed should be low for each pound of water evaporated.
8. A minimum of labor should be necessary for operation.
9. Construction of the dryer should be strong, and the design should be such that the machine can be enlarged if necessary for increased production.
10. The machine should be small, compact, and take up as little floor space as possible for a given production.

IMPROVEMENTS IN LATEST DRYERS

Air Circulation

In contrast to old tenter dryers which had no circulation of heated air, or to those with circulation across the cloth, the new system of "air through" circulation increases efficiency tremendously and provides for the goods being in better condition.

In order to understand the reasoning behind this, we can consider the experience of a certain manufacturer of pile fabrics. He found that goods coming from the dryer had the pile baked. This condition could be traced to the cross circulation of air. Obviously, the pile, or surface of the cloth dried first and became not only dry, but actually baked in the dryer, while the more dense back of the fabric was not yet thoroughly dry. This condition was so extreme in certain instances that the cloth would actually catch fire after leaving the machine, unless means were taken to cool the cloth. In a modern dryer, an experience similar to the above would be impossible, for instead of blowing air across the goods, the air is blown directly *through* the fabric. This "through circulation" may well be considered ideal air distribution, for every individual fiber comes in contact with live, heated air, and therefore, every fiber becomes dry at a uniform rate. It is evident that if there is no slow drying part of a fabric, the production speed will be increased, for drying speed is governed by the slowest part of the cloth to dry.

As each fiber dries at a uniform rate, a high temperature may be used at the feed end of the machine, for the evaporation of moisture will keep the wet bulb temperature at a relatively low point. As the fabric becomes dryer, the temperatures are reduced, so that the material cannot be damaged. As the goods are delivered, it is possible to have them very nearly at room temperature. This cool delivery temperature is brought about by passing cool, fresh air over the cloth before it is folded onto the truck.

The rapidity with which drying is accomplished depends largely on the velocity and pressure of the heated air. The modern dryer therefore depends for its efficiency on a unit which will supply hot air under pressure and direct it uniformly through the fabric. The heart of this unit is the fan.

Fans and Heaters

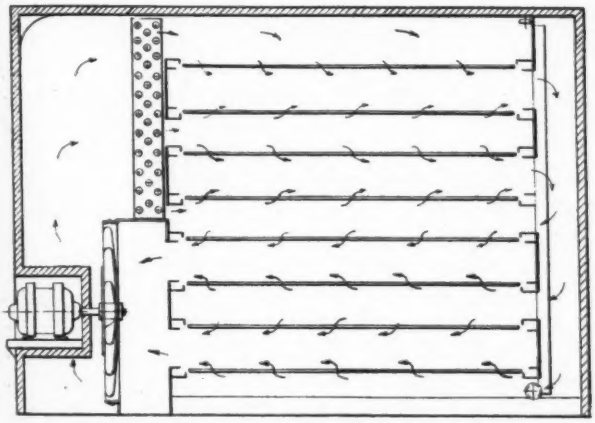
The old style disc fans would supply the volume of air, but they would not supply air under sufficient pressure for "air through" circulation. It was necessary therefore, to develop a fan capable of meeting the particular requirements. By taking advantage of the vast amount of research work in the airplane industry and supplementing this with original experimentation, a fan was developed which is especially suited for modern dryer use.

This fan as now in use, is of the axial flow type, with radially tapered blades. (See illustration.) The blades are curved in the form of the "air foil," the shape so widely

*Sales Engineer, The Philadelphia Drying Machinery Co.

used in airplane construction, the shape and curvature being such that the blade pitch varies throughout the length of the blade. This type of fan gives uniform air flow at all parts of the fan area; eliminates all back flow and maintains high mechanical and static efficiency throughout the entire dryer. The blade is particularly suited for high speed operation from direct connected motors,—the light curved blade, tapering towards the end results in a concentration of weight near the center, rather than the tip, thus reducing centrifugal and vibration stresses to a minimum. Each fan on the latest type machine operates at 1,200 R.P.M. and delivers up to 12,000 C.F. of air per minute, at a static pressure up to ¾".

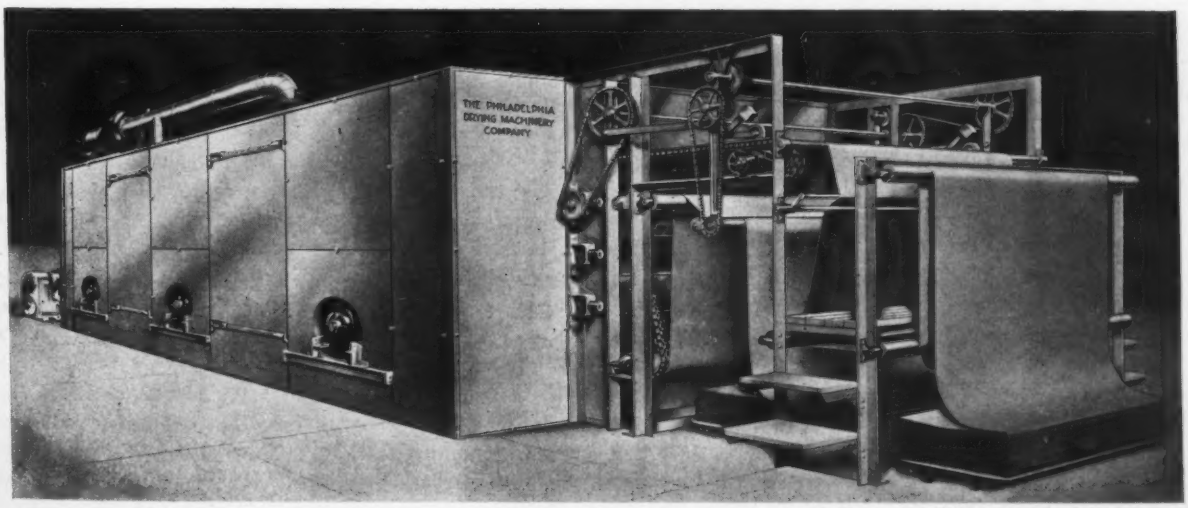
Heating units are of the extended surface type. They are of all welded construction and are situated away from the cloth. Therefore, there is no possibility of leaks damaging the cloth, or of the fabric coming in too close contact with the radiant heat of the coils. Oftentimes, tenters are stopped with cloth in them. When this hap-



Cross section of Hurricane Tenter Dryer. Arrows show circulation of air THROUGH the cloth.

Removable fan and motor assembly of a Hurricane Tenter Dryer. Note the design of the high speed fans which are capable of delivering 12,000 cubic feet of air per minute.

NEW HIGH SPEED HURRICANE TENTER DRYER



Cuts, Courtesy of Philadelphia Drying Machinery Co.

	Old Tenter Dryer	*Modern High-Speed Tenter Dryer*
Power consumption	$.2100/hr. (14 H.P. @ 2c/KWH)	$.3245/hr. (14.5 H.P. @ 2c/KWH)
Steam consumption	$.4000/hr. (800 lbs. @ $.0005)	$.5660/hr. (1132 lbs. @ $.0005)
Labor	$.4200/hr. (1 man)	$.4200/hr. (1 man)
Total cost per hr.	$1.0300	$1.3105
Production per hr.	407 lbs.	1200 lbs.
Cost per lb.	$.00253	$.00109
Savings per lb.		$.00144
Savings per 10-hr. day		$17.30
Savings per year (250 days)		$4320

pened in the old style tenters having steam coils between the passes, the cloth would sag, the center coming in close contact with the coils. The result was over-drying and baking of the center of the cloth. This has always been a well-known source of shady goods.

Humidity Control

The latest tenter dryers are so arranged that the fresh air intake and the moist air exhaust are regulated so that the relative humidity in the dryer is held at a point which has proven, from experience, to be most satisfactory. In other words, if too much air is exhausted, drying will be rapid, but steam consumption will be high; if too little air is exhausted, steam consumption will be slow and so will the rate of drying. A proper balance between exhaust and intake makes for efficient and economical operation.

Heat Losses and Steam Consumption

The enclosures on the most recent machines are so constructed that heat losses through radiation and leakage are small. Panels are made of two sheets of steel between which is interposed one-half inch of effective insulation. The panels are held to the frame against cork seals, which prevent heat loss by leakage. Where older tenter dryers require from 2½ to 3½ pounds of steam to evaporate each pound of moisture, the new dryers use from 1½ to 2 pounds of steam under the same conditions.

Labor Requirements

The machine illustrated will handle goods at speeds up to 40 yards per minute with a single operator. Cloth is automatically guided onto the pins. If by any chance, goods come off the pins, an automatic switch stops the conveyor. The tenter width is increased or decreased by merely pushing a button. The production speed is controlled from the operator's platform and a direct reading indicator gives the speed in yards per minute.

Construction

Modern construction uses structural steel for the framework and tracks. A maximum of strength and lightness is thus provided. Following along the thought that uniform air distribution is essential, the interior is made as nearly streamlined as possible. The inside of the dryer housing presents a flush wall surface with no structural members projecting so as to interfere with air circulation or to collect dirt and flock. Streamline baffles are also provided to direct the air and reduce eddy currents.

Sectional construction is used, the number of sections in a machine being dependent on the production requirements. If a mill needs to increase its capacity, one or more sections can easily be added to a machine. These new machines require but a fraction of the floor space which was formerly needed for a machine of the same capacity.

SUMMARY

A summary of the advance made in modern tenter drying is given in the table above. The "old machine" in the table is based, for fairer comparison, on the average of many tests made on old machines. These machines tested, all had insulated housings and fans for air circulation. The modern high speed tenter used for comparison is the machine which is illustrated. The main body length is 16½ feet.

It should be evident that there are not many new textile machines which will provide so great a return for the money invested. This factor alone is enough to make for modernization of tentering equipment. When the quality of finished fabric is considered, modernization becomes doubly important.

LOCATING OIL WELLS WITH DYES

F. R. Cozzens

IN THE oil producing sections of Ohio, Pennsylvania, and Kentucky, commercial dyes are being used two thousand feet underground in locating new wells. Dyes are used in connection with compressed air, and the practice is proving successful in more than ninety per cent of the cases where pressure can be applied.

Development in these districts reached its peak in 1920, when it first became necessary to apply air pressure to the wells for the purpose of forcing oil through the sand. This practice eventually led to re-drilling, that is, sinking new wells between old ones which were becoming exhausted. Re-drilling, however, is an expensive procedure and before investing his capital, the owner wants to be reasonably sure he is located over a favorable streak.

To obtain this knowledge, the modern operator selects an old well, known to be producing from the streak he wishes to trace. Casing is cleared of all pumping equip-

ment, and down the hole is poured ten to twelve ounces of dye, thoroughly mixed with five gallons of warm water. Any brilliant dye will answer requirements, but the color generally chosen is red. An air compressor is then connected to the well, and air is forced in at a pressure of 300 pounds.

Within a short time, possibly a few weeks, certain old wells in the immediate locality will respond by an increased volume of water or oil. The fluid is examined from day to day, and if it shows globules of dye, the operator knows to a certainty that the well examined is upon exactly the same streak as the well where the dye was first introduced, even though depth and formations may differ. Any location upon a straight line between the two wells is quite sure to strike oil. When certain wells fail to show globules within three months, air pressure is transferred to other wells, and the dye is again introduced in the same manner.

By this procedure it is possible to trace oil streaks for miles with remarkable accuracy. By introducing dye coloring in edge wells it is also a simple matter to find the center of a streak. In production already established, dyes play another very important part by assisting in the location of water seepage into wells. Of all known agents, fresh water is most damaging to oil sands, and when its presence is noticed the operator must act quickly to save his well. Water may occur from leaky casing, or it may be coming through the oil sand itself. To determine its cause, the owner first introduces a solution of dye and water into the hole, outside the casing. If the casing is faulty, coloring globules show up immediately in the fluid pumped from the well. By making temporary bridges of mud at various points down the well, and introducing dyes of different colors, it is easily possible to locate the exact joint of casing where the leak occurs. If no globules are noticed from the outside introduction, a dye solution is poured down nearby wells. Water, if coming through the sand, will eventually bring globules to the well under observation.

In these, and in scores of other ways, commerial dyes are proving a valuable auxiliary in the production of crude oil. Most operators now make them a part of the regular equipment. They are easily put into effect by the average crew, and give satisfactory results at all seasons.

Modernizing the Dyehouse

For Reduced Costs

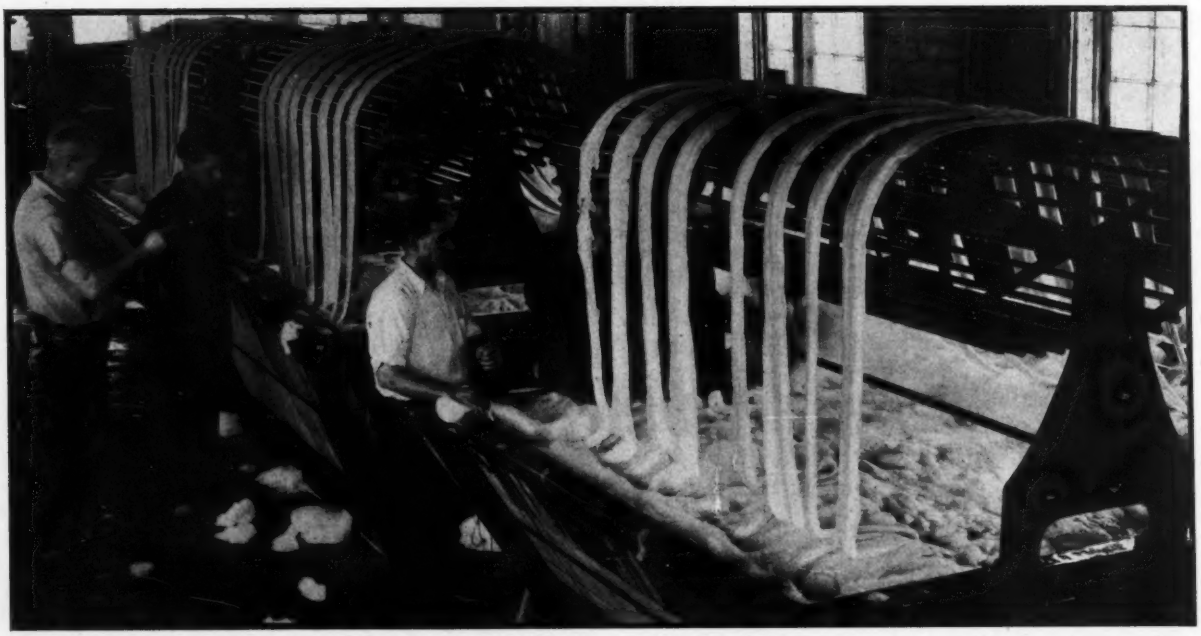
IN DAYS of keen competition all dyehouse costs must be kept at an absolute minimum; one way of doing this is to make certain that all equipment incidental to the operation of a dyehouse is always in good condition and of a type and construction that will facilitate rather than hinder the production of the greatest quantity consistent with good quality. To insure the realization of this fact particular attention should be paid at the time of purchase to the type of material used in the construction of dyehouse equipment. In other words the material selected must be one that is suited to the individual requirements of your particular dyehouse and by keeping all machinery modernized it is possible to cut maintenance and repair costs to the utmost as well as to conduct operations at the lowest possible figure.

An illustration of the benefits of following this policy is found in the case of the Bertram Goldberg, Inc., plant at Johnstown, N. Y. Weighting, finishing and dyeing of silk, rayon, etc., occupy the attention of this plant and thus it does not sell a product but service. It becomes apparent at once that it is an absolute necessity that all costs be kept at a minimum in a plant of this type. In spite of the fact that much of the equipment of this plant has been in use at least ten years and some of it considerably longer, its operating economy and efficiency place it in the class of being one of the most modern of its kind.

Pails were the first item in the modernization program of the Bertram Goldberg plant.

In addition the flexibility of the plant is such that even in dull times its operating costs are only slightly higher per unit produced than when the plant is running at full capacity.

The story of how the modernization policy of this plant made the realization of this fact possible is an interesting one. About 15 years ago Bertram Goldberg became president of the company operating the plant and inaugurated

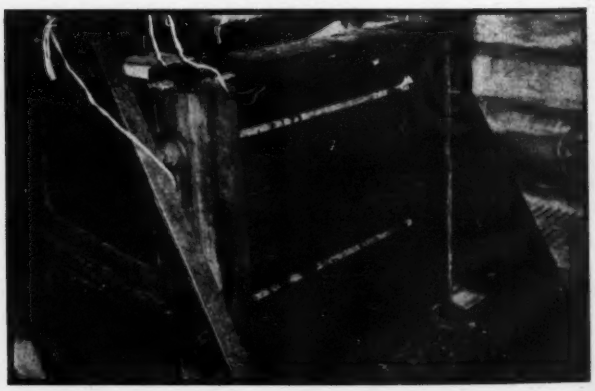


Dyeing machines, lined with Monel Metal and equipped with pure nickel reels, have not cost a cent in upkeep in more than ten years.

Above—Lined tanks for holding the finished fabric require no attention other than an occasional dusting out.
Below—Monel Metal Racks.

Above—Monel Metal Hampers.

Below—Tank for weighting silk. Monel Metal is used for tie rods on tanks constructed of wood. The wooden tanks must be replaced every two years whereas the rods remain in serviceable condition.



Cuts, Courtesy of The International Nickel Co.

a long-range modernization program which was practically all completed before 1929. This fact made it possible for him to measure the value of his program during the depression years. The main point of the program was to eliminate as soon as possible all equipment that required constant maintenance, repair or replacement. The first point of attack concerned the pails used for various mixing purposes. They were made chiefly of galvanized iron which soon corroded from the action of the dyestuffs and other chemicals used. After experimenting with pails of several different materials, a Monel metal pail was tried and served to demonstrate the value of using the proper construction materials in dyehouse equipment. The chief advantages of this pail were found to lie in the fact that it was resistant to the action of the dyestuffs used, required no scouring to clean and did not permit the formation of verdigris.

With this as a start all of the equipment in the dyehouse was eventually brought under the control of the modernization program. Dye tanks, which previously had been constructed of plain wood, wood lined with canvas or wood lined with copper, were next in line. Long boil-outs were necessary in order to change from a dark color to a light color in the plain wood and the canvas lined tubs. They were also difficult to keep clean, operation was costly and replacements were frequent. Although the copper lined tanks were a considerable improvement over the plain wood and canvas lined tank there are numerous colors which are sensitive to the action of this metal with the result that there was loss of time and money due to the production of offshades time and again. In order to improve operations and reduce maintenance costs in the case of the dye tanks experiments were made with other types of tank linings. It was finally decided by the management that Monel metal would work most satisfactorily for the particular production of this plant.

The management also found other advantages of this metal which caused them to standardize on it for practically all of the equipment coming in contact with the dyes and fabrics. It was found that there was considerable saving in space since the same tanks could be used for various classes of dyestuffs as well as for stripping and bleaching. This of course enabled the amount of capital tied up in equipment to be reduced considerably. Other advantages found in this partciular plant were: lowered maintenance costs due to the fact that no repairs have been needed on any of the equipment since its installation; the amount of time required for cleaning out the equipment at the end of a working period was little more than required for flushing out the tanks, naturally working for lower costs; without the present equipment it is stated that it would be impossible to maintain present production at the plant.

One of the most important features of this modernization program manifests itself during the dull seasons when the plant sometimes operates on a three-day-a-week basis. Practically no time is required for cleaning, preparatory to beginning work, even though the apparatus has been idle for several days. Previously it had been necessary to clean all metal equipment thoroughly to remove verdigris before operations could be started and the cleaning had to be repeated regularly while work was in progress. There has been no spoilage of fabrics due to verdigris, rust or other forms of metallic contamination since the modernization program has been in effect. Re-dyes have been practically eliminated and direct, basic, aluminum mordant, acetate and logwood dyes have been used without trouble.

Other dyehouse managers and foremen could well look to their equipment to see if it is not advisable to start a modernization program in their own plants. Savings in time and money are available through this method, to say nothing of the freedom from worry and trouble.

Chemistry of Silk and Silk Processing

(Continued from page 456)

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BOOK REVIEWS

Handbook of Colorimetry. *Prepared by the staff of the Color Measurement Laboratory, Massachusetts Institute of Technology under the direction of Arthur C. Hardy, Professor of Optics and Photography. The Technology Press,* 1936. *Price* $5.00.

The "Handbook of Colorimetry" is the result of three years' work by the staff of the M.I.T. Color Measurement Laboratory under the direction of Professor A. C. Hardy, and its aim is to facilitate the specification of color both in the laboratory and in industry.

Colorimetry is a relatively new science. Until physical instruments were developed which measure color in terms of quantities and wavelengths of light, the only available methods of color specification had of necessity to be based on samples of the various colors. The fact that these samples are subject to change with time, even under the best of conditions, has made it impossible to accumulate an extensive and accurate body of knowledge concerning the diverse phenomena of color and color vision. This handbook is concerned with the basis for the interpretation of the data obtained from physical measurements of colored materials, which may be expressed either in purely physical terms or in terms of the response of the normal observer as defined by the International Commission on Illumination in 1931.

This handbook not only surveys the entire subject of colorimetry for the benefit of those who are approaching the subject for the first time, but also discusses the characteristics of light sources, the physical measurements of colored materials, and the laws of color mixture. The recommendations of the International Commission on Illumination, interpolated to wavelength intervals of one millimicron, are included in this book.

This volume is highly recommended to all who are interested in the scientific aspects of colorimetry and should prove especially valuable to all those who are engaged in fundamental research involving colorimetry and its industrial applications.

The Finishing of Wool Goods. *John Schofield, B.Sc., A.R.C.S., and J. Colin Schofield, B.Sc. (Hons.) Published by the Authors "Moor Croft," Kirkburton, Huddersfield, England.* 1935. *Pages,* 798. *Illustrations,* 340. *Price* 30 *shillings postpaid.*

This book is the outgrowth of three previous volumes of various considerations of the finishing of woolens published respectively in 1921, 1925 and 1927 and combines under one cover all the valuable material contained in the previous volumes with necessary revision and the addition of much new material. The illustrations are excellent and an unusual number of graphs and tables have been introduced.

The whole subject of the finishing of woolen and worsted fabrics is considered in such a complete and scientific manner that the volume may be considered a standard treatise and reference book. The authors should be commended for making available to the textile industry such a vast amount of material in such a ready form for reference and study.

The general aim has been to treat the subject of cloth finishing as a practical art based on scientific principles and in particular, the application of chemistry, physics, and engineering to process work. But the practical man will find minute details for actual operations on the finishing of wool fabrics generally. It has been a special object to give information not generally available from other sources. The subject of wool lubrication, for example—because of its importance in respect of its removal in the scouring processes—receives a detailed treatment which is not found in any current work on yarn spinning proper. Similarly, many subjects of the first importance to mill owners, managers and staff are dealt with, e.g., water for textile purposes, steam and power, machine construction, etc. But it is further claimed that it is abreast—and in many respects in advance of—current research work. In the end, practical production in the mill settles all research questions.

The authors have recognized that the quick sales of the previous works have assisted them in the improved scope of the later books. The new work is much larger than its predecessor. It is hoped that its service to the industry will enable it to repeat that success, and in due course itself make way for revision in accordance with still newer researches. The authors take the opportunity of acknowledging their gratitude to all whose information, help and cooperation have enabled them to carry a rather heavy task to a successful conclusion. In particular, patent specifications appear by permission of the authorities.

The completeness of this work will be realized from the list of chapter headings which follows:

I. Water for Textile Purposes.
II. Steam and Power in the Finishing Shed.
III. Wool and Chemical Reagents.
IV. The Chemistry of Oils and Fats.
V. Soaps and Other Detergents.
VI. Theory of Detergent Action.
VII. Soap Solutions.
VIII. Practical Scouring.
IX. Felting, Fulling and Milling of Wool.
X. Chemistry and Physics of Wool.
XI. Minor Processes.
XII. The Blowing Process.
XIII. Wool and Moisture.
XIV. The Drying Processes.
XV. The Shearing or Cutting Process.
XVI. The Raising Process.
XVII. The Pressing Process.
XVIII. Defects, Damages and Stains.
XIX. Finishing Routines.

NEW PRODUCTS—TRADE NOTES

• FLOOR TRUCKS

A new, fully illustrated circular, No. 220, on easy-rolling floor trucks for factory and warehouse, used extensively by manufacturers, warehouses and distributors for interior transporting every type of product, merchandise, or goods, has just been issued by Lewis-Shepard Co. of Watertown, Mass. Several new types of Caster Trucks, Rubber-Tired Trucks and Shelf Trucks are shown. Copies of this circular showing many new types of floor trucks gladly sent to anyone.

• FLAMEPROOFING MATERIAL

The Glyco Products Co., Inc., has announced release of a flameproofing liquid known as Abopon. When dissolved in water it can be sprayed on the materials to be treated or they can be dipped in the solution as desired. It is stated that cloth treated with this product retains its flameproofing characteristics almost indefinitely and can be dry cleaned with safety. It is also stated that Abopon does not rot or tender the material. Complete details are available on request.

• WATER REPELLENT FABRICS

Every indication points to a still further increasing public demand for fabrics that are water repellent, according to reports made by the du Pont Company. This growing demand is shown by important orders for their new water repellent known as "Aridex."

Demand for certain improved qualities in water repellents has resulted in the development of new characteristics in these materials, say the du Pont experts. A mere water repellent is not enough to meet public demand, as such products too often, under certain conditions, lose their efficiency. Recent developments in the du Pont laboratories have produced what is now, in effect, a new process which, it is claimed, does not coat the fabric nor in any way affect its appearance or feel. It is stated that it simply covers the fibers with an invisible film, so thin it cannot be felt by the hand. Fabrics treated with this process therefore remain unsealed, permitting normal, healthful circulation of air, it is claimed.

The question of permanency of this process on fabrics is a matter that is giving chemists opportunities for considerable research work. The new type of water repellent finish has been aimed to insure permanency when used on fabrics which are not to be dry cleaned or laundered frequently, such as upholstery fabrics and similar materials. The du Pont Company chemists believe that several careful launderings in water not in excess of 100 degrees Fahrenheit will not ordinarily impair the "Aridex" finish. They say that fabrics treated with this process will withstand six to eight careful launderings without great loss of water repellency.

Reports from the field indicate an interest in water repellents unparalleled in the textile industry in years.

• FULTON RELEASE

Fulton Dye & Import Co. announces release of the following new product:

Dispersole Whyteray—a new development for textile printing especially for discharge work and the production of whites upon pigmented rayon particularly, as well as all other types of rayon fabric, including cotton and rayon mixtures. It is a white pigment prepared and ready for use and in an exceptionally finely divided state and said to be entirely free from gritty matter that might tend to scratch copper rolls. It is stated that this product will yield, on the above mentioned fibers, an opaque white in an economical way which is similar in all respects to the white that has been demanded by the trade, duplicating the whites that were so much required in the silk trade. It is further stated that this present pigment is very much changed from the original method of producing white pigments and that advantage has been taken of the recent improvements in colloidal chemistry and dispersion. The product is applied by the addition of hydrogum and albumen; the discharge print is subsequently aged and washed, no special formulas being required.

The Fulton company also announces a series of dispersole toners in a rather complete range of shades. These are also along the line of the white pigment except that they are in colored form. The light fastness of these toners is said to be of the best and the washing fastness, dependent upon the mechanical fixation with albumen, to be reasonably good for the majority of purposes.

Annual Meeting and Convention A.A.T.C.C. Providence, R. I. December 4 and 5 Headquarters: Biltmore Hotel

• NEW PLANT

Carolina Aniline & Extract Co. announces completion of the first unit of their new plant, offices and laboratories. It is of all steel and asbestos construction and it is understood that this is the first plant of this type of construction erected in the United States. It was built particularly

Inside View of Laboratory.

for the manufacture of all types of sulfonated oils, titanium products and various types of finishing compounds for the Southern textile trade. It is stated that asbestos was used throughout because of its flexibility, heat and cold insulation, and protection from fire hazards. It was constructed on the Ambler Olsen System and designed especially for sulfonating during the extreme heat incurred in the South during the summer. It is situated on one of the main streets of Charlotte, N. C., with railroad siding, on a plot of ground covering two and a third acres. Sufficient ground is available for the erection of six similar units should it be found necessary.

Outside View of Office and Plant of Carolina A. & E. Co.